3.5 SURFACE WATER HYDROLOGY

Surface water within the proposed Project Area, including the mine area and associated transportation and proposed pipeline corridors, includes numerous rivers, streams, lakes and wetlands. Wetlands in the proposed Project Area are discussed in detail in Section 3.11, Wetlands. The types of rivers and stream channels found within the proposed Project Area include braided channels, split channels, alluvial fans, and single channels.

This section first summarizes regulations pertaining to surface water hydrology, and then examines each component of the proposed project in turn. Specifically, under each component, the section identifies potentially affected drainages, and discusses water balance modeling, flooding, and proposed use of surface waters.

SYNOPSIS

This section examines surface water resources, or water bodies and flow, of the proposed Project Area. While all three proposed project components interact with surface water to some degree, the proposed mine site would change surface water hydrology in and around the mine. The section looks at applicable laws, potentially affected drainages, water balance models, and proposed use of surface water, before turning to expected effects.

Summary of Existing Conditions:

Regulatory Framework: Four federal and four state regulations, including the Clean Water Act (CWA), the Rivers and Harbors Act, Executive Order 11988, and portions of Alaska Administrative Code (AAC) all pertain to surface water for the proposed project.

Drainages and Water Balance Modeling: Seventeen drainages feed Crooked Creek in the proposed mine site area. (Figure 3.5-1) Of these, 6 drainages, representing about 8 percent of the surface drainage area for Crooked Creek, would be affected by activity at the proposed mine site. Water balance modeling is a way to look quantitatively at water in and water out of a system, taking into account a wide range of parameters such as precipitation, snow melt, temperature, and evaporation. In a process of calibration, the mathematical model selected for analyzing water supply and use for the mine was tested against baseline data, yielding results well within accepted industry standards.

Use of Surface Water: Each component of the proposed project would use surface water or affect surface water hydrology. Existing uses for domestic and industrial supply, in-stream flow reservations, and water rights ownership are described for each project component.

Expected Effects:

Alternative 2: Donlin Gold's Proposed Action – Surface water hydrology would be most dramatically affected within the proposed mine site. Under this alternative, surface water amount and flow would be altered during every project phase in Snow Gulch, Lewis Gulch, American Creek, Omega Creek, Unnamed Creek SE1, and Anaconda Creek (Figure 3.5-1) through damming, pit dewatering, and other diversions. Approximately 4.7 miles of fish-supporting stream habitat and 5.6 miles of smaller, non-fish-supporting stream habitat would be lost. Affected drainages account for about 8 percent of the Crooked Creek watershed.

Effects on Crooked Creek flow could vary widely depending on season, precipitation conditions, bedrock hydraulic conductivity (K), phase of mine operations, and distance from the mine. For example, Crooked Creek flow below the mine site near Crevice Creek would be reduced by 20 percent in winter under average precipitation and K conditions, and by 26 percent in dry conditions, during late operations (year 20 onward). The greatest flow reduction experienced near the mouth of Crooked Creek (at Bell Creek about 8 miles downstream of the mine) is projected to be 4 to 10 percent under the above conditions. In the event that K is higher than expected, 45 to 100 percent of Crooked Creek flow could be reduced in winter near the mine site under average to dry precipitation conditions, with much of the flow restored below Crevice Creek (16 to 40 percent reductions) due to tributary inflows. Reshaped topography would permanently alter surface flow at the mine site.

Beginning at closure, surface water from the TSF and Seepage Recovery System (SRS) would be diverted to the pit. Around year 52 after closure, water from the filling pit lake would be pumped to maintain freeboard and hydraulic containment of all contact water, and would be directed through a treatment plant prior to release into Crooked Creek, a condition that is expected to be permanent.

Surface water impacts from the proposed Transportation Facilities would range from low intensity for drainage alterations at culvert installations, to medium intensity for riverbed scour effects. Impacts from the Pipeline would be primarily during construction, when construction crews and activities would draw on local surface water in the area of activity, and when surface water flows could be temporarily altered. Because the high-impact and long-term to permanent effects on surface hydrology are limited to the immediate environs of the proposed mine site, the overall effect is considered to be moderate. The magnitude of expected effects by alternative and phase are described below, using Alternative 2 as a reference point.

Other Alternatives: The effects of other alternatives on surface water hydrology would be similar to those of Alternative 2. Differences of note include:

- *Alternative 3A (LNG-Powered Haul Trucks)* would decrease the number of fuel barge trips per season from 58 to 19, reducing transportation impacts to hydrology within the Kuskokwim River. Similarly, fuel storage requirements in Bethel and at the proposed Angyaruaq (Jungjuk) Port would be lessened, with proportionally smaller effects to surface water from runoff from disturbed soil. These differences would not alter the overall magnitude of effects.

- *Alternative 3B (Diesel Pipeline)* has similar differences in effects to those of Alternative 3A. Fuel storage capacity at Angyaruaq (Jungjuk) would not be decreased from

Alternative 2, due to construction period needs, and some additional impacts to surface hydrology would occur during construction of the overhead Tyonek-to-Beluga portion of the diesel pipeline. Once the diesel pipeline was complete, fuel barging on the Kuskokwim River would be completely eliminated. Overall magnitude would not change.

- *Alternative 4 (Birch Tree Crossing Port)* would create a river port about 69 river miles south of the proposed port under Alternative 2. The mine access road would be 2.5 times as long, crossing 43 streams, as opposed to 40 under Alternative 2. The amount of fuel being barged would not be reduced, however fewer shallow sections of river would need to be traversed, leading to slightly lower scour impacts on riverbed sediment. Overall magnitude would not change.
- *Alternative 5A (Dry Stack Tailings)* would exchange a dry stack and operating pond design for the wet tailings design of the Tailings Storage Facility under Alternative 2. This would alter the flow of surface water within the mine during construction, operations, closure, and post-closure. More contact water would be stored and used in milling, resulting in a roughly 25 percent increase in discharge of treated water to Crooked Creek during operations. Post-closure, water flow in the reclaimed mine site would be different from Alternative 2, but the downstream effects would be the same. Approximately 6 percent higher barge traffic would be needed to support the additional earth moving equipment and operations and filter plant. Overall magnitude of effects would not change.
- *Alternative 6A (Dalzell Gorge Route)* would reduce the number of stream crossings of the natural gas pipeline from 400 to 377. It would include a 2-mile Horizontal Directional Drilling undercrossing through Dalzell Gorge. This reduction in stream crossings would not change the overall magnitude of effects on surface hydrology.

3.5.1 APPLICABLE REGULATIONS, WATER USE/FLOW

Construction and operation activities of the proposed project have the potential to affect surface water resources. Surface water resources are regulated by federal and state agencies, and corresponding water use regulations are summarized in Table 3.5-1. Regulations specifically governing water quality are described in Section 3.7.1, Water Quality, regulations related to soils and erosion are described in Section 3.2.1, Soils, and regulations related to Fish Habitat are described in Section 3.13.1.2, Fish and Aquatic Resources.

Water use limits are set in Alaska Statute (AS) 46.15, and in 2013, Donlin Gold submitted applications for Temporary Water Use Authorizations for water use, withdrawal, impoundment, and diversion.

Table 3.5-1: Federal and State Surface Water Use Regulations

Agency and Permit Type	Regulation	Description
Federal		
Corps: Navigable Waters of Dredge and Fill Permit	Section 10 of the Rivers and Harbors Act	Requires authorization from the Corps for the construction of structures in or over any navigable water of the United States, including excavation, dredging or deposition of material in this water, or any obstruction or alteration in navigable water.
Corps and EPA: Dredge or Fill Material	Section 404 of the Clean Water Act	Regulates the discharge of dredged or fill material into waters of the United States. Waters of the United States include tributaries to navigable waters, interstate wetlands, wetlands which could affect interstate or foreign commerce, and wetlands adjacent to other waters.
USCG: Bridge Permit	Section 9 of the Rivers and Harbors Act	Construction of any obstruction in U.S. navigable water requires authorization from the Corps. Authority to administer Section 9 for bridges and causeways is delegated to USCG.
All Federal Agencies: Floodplain Management	Executive Order 11988	To the extent possible, federal agencies must take action to avoid long- and short-term adverse impacts to floodplains. Agencies must take action to reduce the risk of flood loss and minimize impacts of floods on human safety, health, and welfare, and restore and preserve beneficial effects served by floodplains.
EPA: Protection of Wetlands	Executive Order 11990	Avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative.
State of Alaska		
ADEC: Dredge or Fill Material	18 AAC 70 (Section 401 of the Clean Water Act)	Water quality certification for placement of fill or dredged material into waters of the United States, obtained concurrent with Section 404 Permit.
ADEC: Public Drinking Water Systems and protection areas	18 AAC 80 (and federal 40 CFR Part 141, 40 CFR Part 142, and 40 CFR Part 143)	Alaska has primacy on regulating public drinking water systems with many references to federal regulations. Regulations also contain references to Drinking Water Protection areas that have been mapped for many public drinking water systems.
ADNR: Temporary Water Use Authorization or Water Rights	AS 46.15	Temporary Water Use Authorizations and/or water rights permits and certificates are needed for use of a significant amount of water. This may apply to the mine and process facility's water use, camp water use, dust control, pipeline construction or testing, ice roads, mine dewatering, water extraction, treatment, and discharge, and all other water diversions.
ADNR: In-stream flow reservations	11 AAC 93.141-147	In-stream flow reservations may be filed with ADNR by interested parties for maintaining stage or discharges in streams or rivers or maintaining minimum levels in lakes.

Table 3.5-1: Federal and State Surface Water Use Regulations

Agency and Permit Type	Regulation	Description
ADFG: Fish Habitat Permits	AS 16.05.841-871	A Fish Habitat Permit is required before any action is taken to construct a hydraulic project; use, divert, obstruct, pollute, or change the natural flow or bed of a specified river, lake, or stream; or use wheeled, tracked, or excavating equipment or log dragging equipment in the bed of a specified river, lake, or stream.

Notes:
ADEC – Alaska Department of Environmental Conservation
ADFG – Alaska Department of Fish and Game
ADNR – Alaska Department of Natural Resources
EPA – Environmental Protection Agency
Corps – United States Army Corps of Engineers
USCG – United States Coast Guard

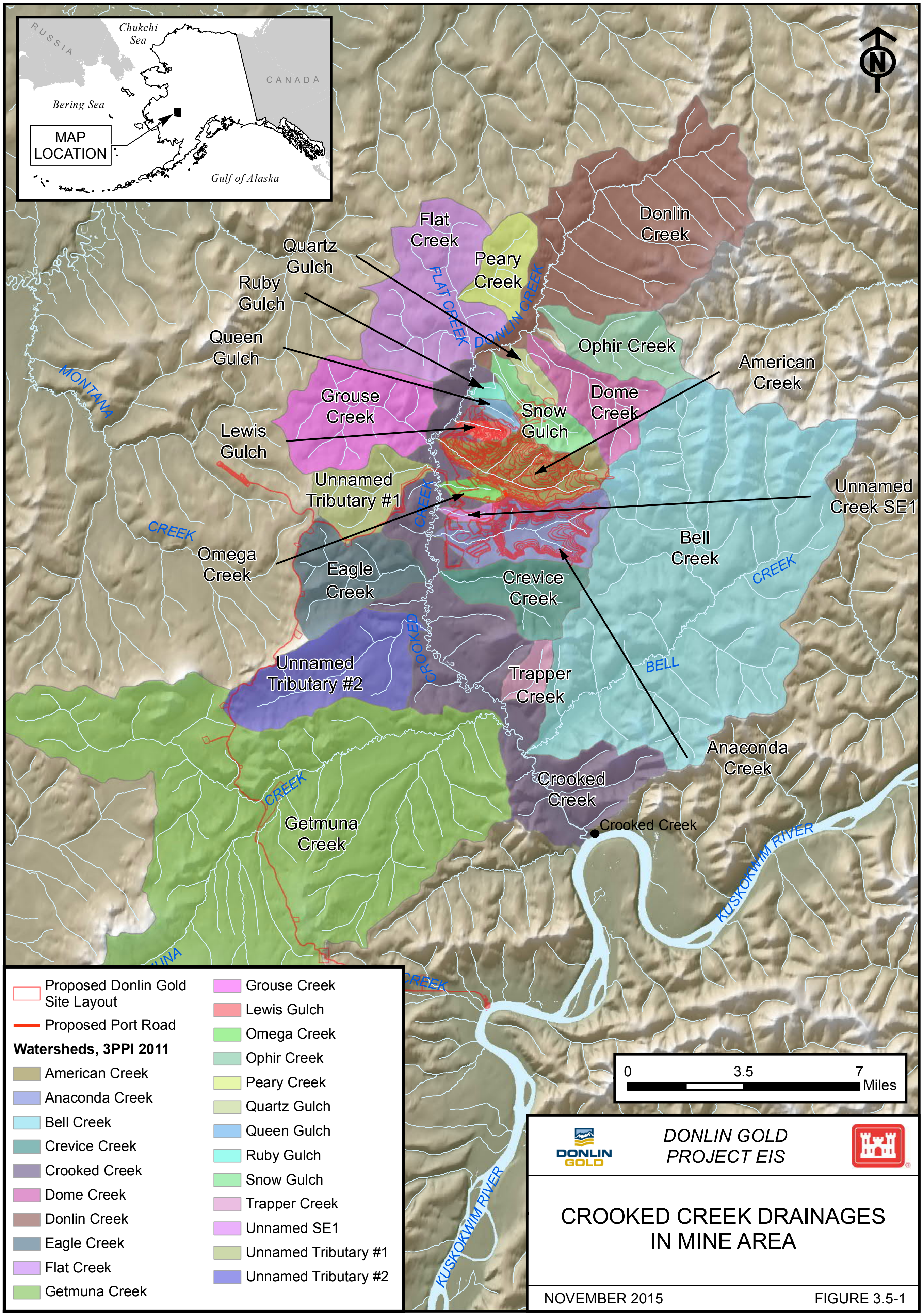
3.5.2 AFFECTED ENVIRONMENT

3.5.2.1 MINE SITE

The proposed Donlin Gold Project mine site would be located within the Crooked Creek drainage, a tributary of the Kuskokwim River (Figure 2.3-12 in Chapter 2, Alternatives). Crooked Creek flows south to its confluence with the Kuskokwim River at the village of Crooked Creek. The proposed mine site would be located in the northern portion of the Crooked Creek watershed, along the east side of Crooked Creek. The majority of the proposed mine pit and WRF would be located in the American Creek watershed, and the TSF would be located within the Anaconda Creek watershed, both tributaries to Crooked Creek. Other mine-related development such as roads, overburden stockpiles, freshwater reservoirs and ponds would occur in smaller tributary catchments including unnamed creek (SE1), Omega Gulch, Lewis Gulch, Queen Gulch, and Snow Gulch (Figure 3.5-1). During the post-closure period, Crevice Creek would receive flows diverted from the Anaconda Creek drainage. However, there would be no mine-related infrastructure in the Crevice Creek drainage.

3.5.2.1.1 DRAINAGE BASINS/WATERSHEDS

Drainage basin characteristics of Crooked Creek and respective tributaries within the area of the proposed mine site and related developments are described in this section and listed in Table 3.5-2.



CROOKED CREEK DRAINAGES IN MINE AREA

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FIGURE 3.5-1

Table 3.5-2: Drainage Basin Characteristics, Crooked Creek and Tributaries

Drainage Basin	Drainage Area (square miles)	Channel Length (miles)	Basin Relief (feet)	Mean Basin Elevation (feet)
Snow Gulch	3.3	2.6	420 to 1,882	1,015
Queen Gulch	0.9	1.6	387 to 1,410	895
Lewis Gulch	0.8	1.5	359 to 1,411	807
American Creek	6.5	4.1	341 to 2,083	1,004
Omega Gulch	0.9	1.7	325 to 1,006	645
Unnamed Creek (SE1)	0.7	1.5	303 to 1,002	622
Anaconda Creek	7.6	3.6	300 to 1,425	734
Crevice Creek	7.0	4.1	312 to 1,507	726
Crooked Creek	336	49.3	135 to 3,610	856

Source: Calculated in AutoCad Civil 3D based on USGS (2013a) Digital Elevation Model (DEM), National Hydrography Database (NHD 2012), and watershed boundaries from Arcadis (2012a).

Lewis Gulch, Queen Gulch, and Snow Gulch

The northern portion of the mine pit and part of the northern overburden stockpile would be located in Lewis Gulch, a small tributary of Crooked Creek north of American Creek (Figure 2.3-1 in Chapter 2, Alternatives). A portion of the northern overburden stockpile would also extend into Queen Gulch, north of Lewis Gulch. Both Lewis and Queen gulches have catchment areas of less than one square mile, main channel lengths of approximately 1.5 miles, and based on streamflow data, appear to exhibit intermittent flow regimes. Lewis Gulch has a mean basin elevation of 807 feet and the Queen Gulch mean basin elevation is 895 feet. The lower end of Queen Gulch has been disturbed by placer mining and the stream flows over the tailings, dropping about 8 feet onto the Crooked Creek floodplain. Above the mined area, the stream is small and the gradient is relatively steep (OtterTail Environmental Inc., 2007).

The Snow Gulch drainage is a small tributary of Donlin Creek, and would be the location of a proposed water supply pond and dam (Figure 2.3-1 in Chapter 2, Alternatives). The Snow Gulch drainage area is 3.3 square miles, and has a main channel length of 2.6 miles and mean basin elevation of 1,015 feet. The lower end of the Snow Gulch drainage has been re-routed due to placer mining activity, but above the existing mined area the stream is essentially undisturbed (OtterTail Environmental Inc. 2007).

American Creek

The American Creek watershed is the proposed location of the mine pit and waste rock storage facility (Figure 2.3-1 in Chapter 2, Alternatives). The American Creek watershed is approximately 6.5 square miles in area and ranges in elevation from 341 feet to 2,083 feet, with a total basin relief of approximately 1,842 feet and mean basin elevation of 1,004 feet. The main channel length is approximately 4.1 miles. Beaver activity is present throughout the drainage, which causes the stream channel to be braided in many areas (NES, 1996). The stream channel is moderately sinuous, narrow, and incised with a gravel bottom in areas not affected by beavers.

Unnamed Creek (SE1) and Omega Gulch

An unnamed tributary (labeled as SE1) and Omega Gulch are small tributary catchments of Crooked Creek upstream of Anaconda Creek (Figure 3.5-1). Both have watershed areas less than 1 square mile in area, main channel lengths of approximately 1.5 miles, and have intermittent flow regimes. Unnamed Creek SE1 has a mean basin elevation of 622 feet and the Omega Gulch mean basin elevation is 645 feet. The southern overburden stockpile would be located between the two tributaries, and both would be crossed by mine access roads (Figure 2.3-1 in Chapter 2, Alternatives).

Anaconda Creek

Anaconda Creek is the southernmost tributary of Crooked Creek to flow through the proposed mine site, and would be the location of the TSF (Figure 3.5-1). The Anaconda Creek watershed covers approximately 7.6 square miles and ranges in elevation from 300 feet to 1,425 feet, with a total basin relief of approximately 1,125 feet and mean basin elevation of 734 feet. The main channel length is approximately 3.6 miles. Anaconda Creek is moderately sinuous, with a relatively deep, incised channel and undercut banks. The channel bed and bank material is predominately silt and sand. Woody debris is common within the channel, likely due to the erosive nature of the bank material (OtterTail Environmental Inc. 2007).

Crevice Creek

The Crevice Creek watershed, while not part of the proposed mine development, would receive runoff water from the closed TSF following completion of mine closure activities. Crevice Creek watershed is similar in size and shape to the Anaconda Creek watershed (Figure 3.5-1). The Crevice Creek watershed covers 7 square miles and ranges in elevation from 312 feet to 1,507 feet, with a total basin relief of approximately 1,195 feet and mean basin elevation of 726 feet. The main channel length is approximately 4.1 miles. The Crevice Creek channel is narrow and incised, with very few deep pools. Channel bed material consists of gravel, cobble, and silt (OtterTail Environmental Inc. 2007).

Crooked Creek

The upstream end of Crooked Creek is at the confluence of Donlin Creek and Flat Creek (Figure 3.5-1). The Crooked Creek watershed covers 336 square miles and ranges in elevation from 135 feet to 3,610 feet, with a total basin relief of approximately 3,475 feet and a mean basin elevation of 856 feet. The main channel length is approximately 49 miles. The morphology of Crooked Creek between Anaconda Creek and the Donlin Creek / Flat Creek confluence is typical of a low gradient sinuous stream, characterized by riffle-pool channel types (OtterTail Environmental Inc., 2007). Channel bed material in the steeper riffle sections is predominately coarse gravel and sand, and in the lower gradient pool sections is predominately sand and silt. Downstream of Anaconda Creek, the Crooked Creek gradient becomes less steep and is highly sinuous.

Placer mining activities have occurred, or are currently taking place, in several of the tributary streams in the upper Crooked Creek drainage, including Quartz, Snow, Lewis, and Queen gulches (OtterTail Environmental Inc. 2007).

3.5.2.1.2 STREAM FLOW

Stream flow in Crooked Creek and its tributaries is generated from a combination of rainfall and runoff, snowmelt, and groundwater discharge. The flow regime of streams in the proposed Project Area includes both ephemeral and perennial systems. Base flows in these streams are the result of groundwater discharge, and higher flows are a result of precipitation events, as well as snowmelt during spring breakup. The Crooked Creek watershed is generally undisturbed; however, historic and current placer mining operations exist. Placer mining occurs in the Donlin Creek, Snow Gulch, Queen Creek, and Lewis Creek tributaries of the upper Crooked Creek watershed. Baseline surface water conditions at the proposed mine site, which establish parameter concentrations from both natural and anthropogenic sources, are presented in Section 3.7.2, Water Quality.

<u>Gauging Stations</u>

Stream flow monitoring has been conducted on Crooked Creek and its tributaries in the vicinity of the proposed mine operations for a number of years. Stream gauging stations that collect continuous flow data are listed in Table 3.5-3 along with the period of record, and Figure 3.5-2 shows where the stations are located. Surface water hydrologic data collection sites vary from the surface water quality monitoring sites because they are achieving different goals (SRK 2012c). Additional rationale for stream monitoring is provided in Table 3.7-1 (Section 3.7, Water Quality). Gauging stations with data prior to 2005 were originally established by the mining company Placer Dome. As the project progressed, understanding of both stream flow and water quality conditions from the respective basins increased. In 2005, Donlin Gold redesigned the sampling plan to include the addition of new surface water monitoring stations and to remove others. The expanded stream monitoring network included installation of sites on Snow Gulch (upstream), American Creek (mid and upstream), Upper Anaconda Creek, and the Crevice Creek drainage (to the south of the proposed facilities) (SRK 2012c). In addition to these, a USGS gauging station is located on lower Crooked Creek about 8 miles below the proposed mine site. Continuous flow data, recorded during the open-water season (typically June through October) in 15-minute to daily increments, are available at a number of the stations. Minimal discharge measurements have been taken during the winter period due to the formation of thick channel ice in Crooked Creek and its tributaries (BGC 2011f).

In addition to the continuous gauging station data, periodic manual stream flow measurements have been collected at the following locations:

- The upper drainages of Snow Gulch and American, Anaconda, and Crevice creeks;
- Several additional tributaries to Crooked and Donlin creeks, including Dome, Flat, Grouse, Eagle, Getmuna, and Bell creeks; and Quartz and Omega gulches;
- Two additional sites in Crooked Creek near the proposed mine site (CCBW and CCBC);
- Two sites on lower Crooked Creek (CCBB and CCAK);
- At several ongoing gauging stations (AMER, ANDA, CCAC, CRDN, and DCBO) to develop rating curves for the continuously recorded data; and
- At monitoring locations in Snow Gulch and Crooked Creek (SNOW and CCBO).

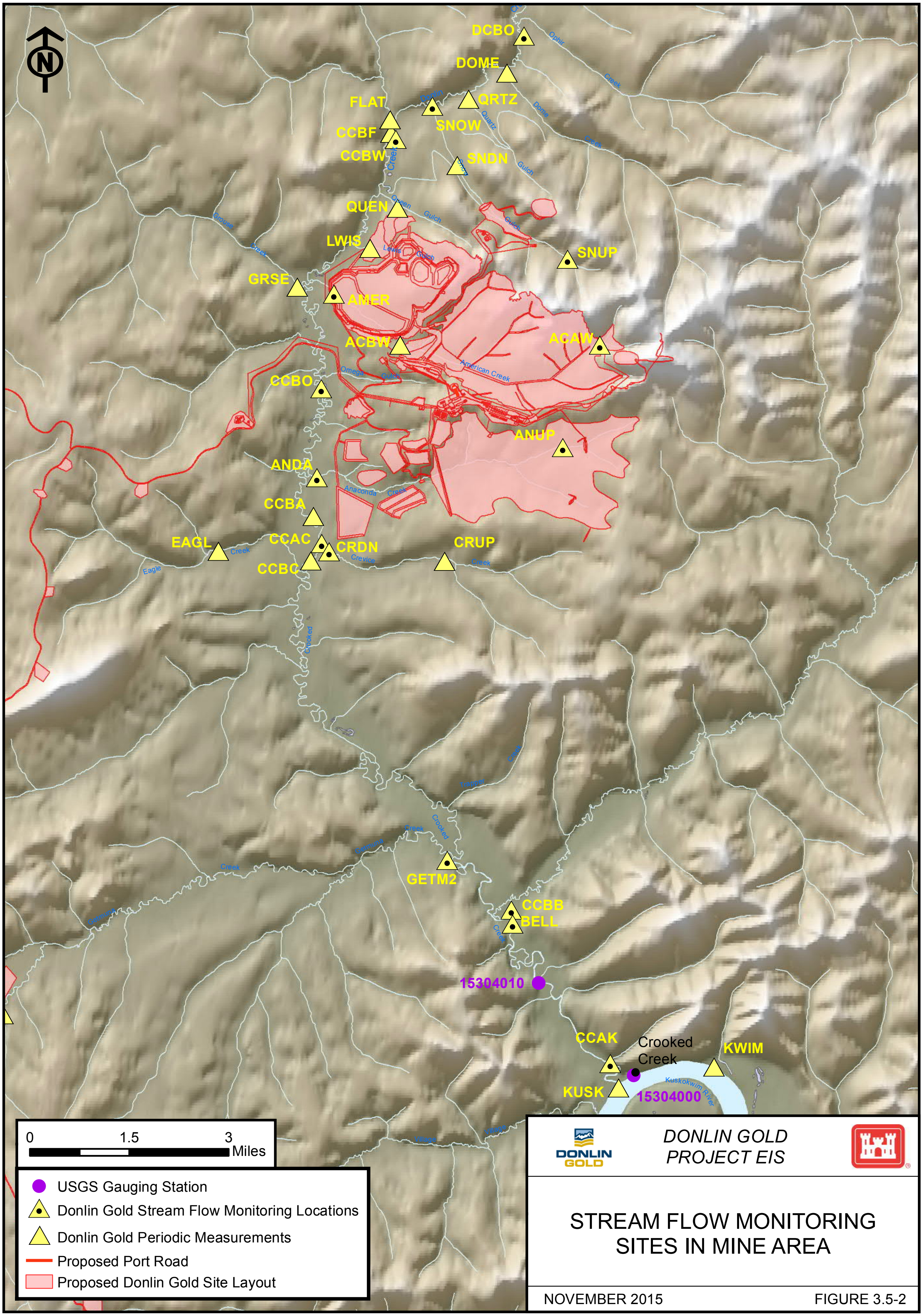
Table 3.5-3: Stream Flow Gauging Stations, Crooked Creek Drainage

Station	Area (mi²)	Period of Record
Donlin Creek below Ophir Creek (DCBO)[1]	35.4	1996-2000, 2002, 2005-2011
Snow Gulch above the confluence with Donlin Creek (SNOW)	3.4	1996-2000, 2002-2003, 2005-2011
Queen Gulch above the confluence with Crooked Creek (QUEN)	0.87	1996-2000, 2002-2003
Lewis Gulch above the confluence with Crooked Creek (LWIS)	0.83	1996-2000, 2002-2003
American Creek above confluence with Crooked Creek (AMER)[1]	6.8	1996-2000, 2000-2003, 2005-2009, 2011
Crooked Creek below Omega Creek (CCBO)	99.9	1996-2000
Anaconda Creek above confluence with Crooked Creek (ANDA)[1]	7.6	2002-2003, 2005-2011
Crooked Creek below Anaconda Creek (CCBA)	108.0	June 25 to July 13, August 7 to October 10, 2003
Crooked Creek above Crevice Creek (CCAC)[1]	112.0	2005-2011
Crevice Creek above the confluence with Crooked Creek (CRDN)[1]	6.98	2009-2010

Notes:
1 Streamflow data have continued to be gathered by Donlin Gold at these stations beyond 2011.
Source: BGC (2012a).

Snow Gulch

Snow Gulch, north of Queen Gulch, is the proposed location of a fresh water dam that would be used as a contingency source of fresh water for the mine's process plant (BGC, 2011g). The Snow Gulch watershed has a drainage area of 3.4 square miles. Periodic discharge measurements made in the Snow Gulch stream are provided in Table 3.5-4, which lists the minimum and maximum discharge measured during the open-water season (BGC, 2012a). Periodic streamflow measurements were taken between 1996 and 2000, and 2002 and 2003. Between 2005 and 2011, streamflow measurements were taken annually during both open water and winter conditions. The minimum and maximum discharge recorded during the 2005-2011 open water monitoring period was 2.5 and 11.2 cubic feet per second (cfs), respectively (Table 3.5-4).



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STREAM FLOW MONITORING SITES IN MINE AREA

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FIGURE 3.5-2

Table 3.5-4: Snow Gulch Minimum and Maximum Discharge at Station SNOW

Date	Minimum Discharge (cfs)	Date	Maximum Discharge (cfs)
7/19/2005	2.6	**9/23/2005**	10.1
7/18/2006	4.9	**9/18/2006**	5.1
6/12/2007	3.8	**9/12/2007**	4.4
8/24/2008	3.5	**6/9/2008**	7.8
9/8/2009	2.5	**6/4/2009**	6.7
6/10/2010	4.8	**9/5/2010**	11.2
9/16/2011	3.0	**5/31/2011**	4.1

Notes:
Data for open-water season only.
Source: BGC 2012a.

Periodic discharge measurements were taken in the Snow Gulch stream during winter months between 2006 and 2011. The minimum discharge during the winter months was 0.1 cfs, and the maximum discharge was 3.4 cfs (BGC 2012a).

Lewis and Queen Gulches

Periodic discharge measurements were made on streams in Lewis and Queen gulches (Figure 3.5-2), during the open-water season between 1996 and 2003. These streams drain the northern portion of the proposed mine footprint. Lewis Gulch, a small tributary north of American Creek, has a drainage area of 0.8 square miles. The minimum discharge observed in Lewis Gulch was 0.24 cfs, and the maximum discharge was 4.74 cfs. Queen Gulch is located north of Lewis Gulch, and has a drainage area of 0.9 square miles. The minimum discharge observed in Queen Gulch was 0.30 cfs, and the maximum discharge was 4.25 cfs (HMH 2004).

American Creek

Stream flow data were collected on American Creek (Figure 3.5-2) during the open-water season between 1996 and 2011; however, no data were collected in 2001 and 2004. The stream gauging station (named AMER) is located upstream from the confluence with Crooked Creek at the downstream edge of the proposed mine pit. The channel at the gauging station is approximately 5 feet wide and 3 feet deep, and the drainage area at this location is 6.8 square miles (BGC 2012a). The long-term average daily discharge between June 1st and September 30th is presented on Figure 3.5-3. The overall average discharge for this period was 11 cfs. In addition to the long-term average, hydrographs from 1998 and 2009 are included on Figure 3.5-3 to show the discharge variability on a seasonal basis. In 2009, average daily discharge was lower than the long-term average, with an overall average discharge of 5 cfs, indicating a dryer than average year. The maximum average daily discharge for the period of record occurred in early July of 1998, and was measured at 119 cfs.

Between 2009 and 2011, attempts were made to characterize low-flow conditions during winter months (November through April) on American Creek. Discharge ranged from zero flow (ice) to 2.9 cfs.

Average monthly discharge during open flow months on American Creek is listed in Table 3.5-5. Average monthly flow varied between 2.8 and 20.6 cfs during the monitoring period.

Table 3.5-5: American Creek Average Monthly Discharge at Station AMER

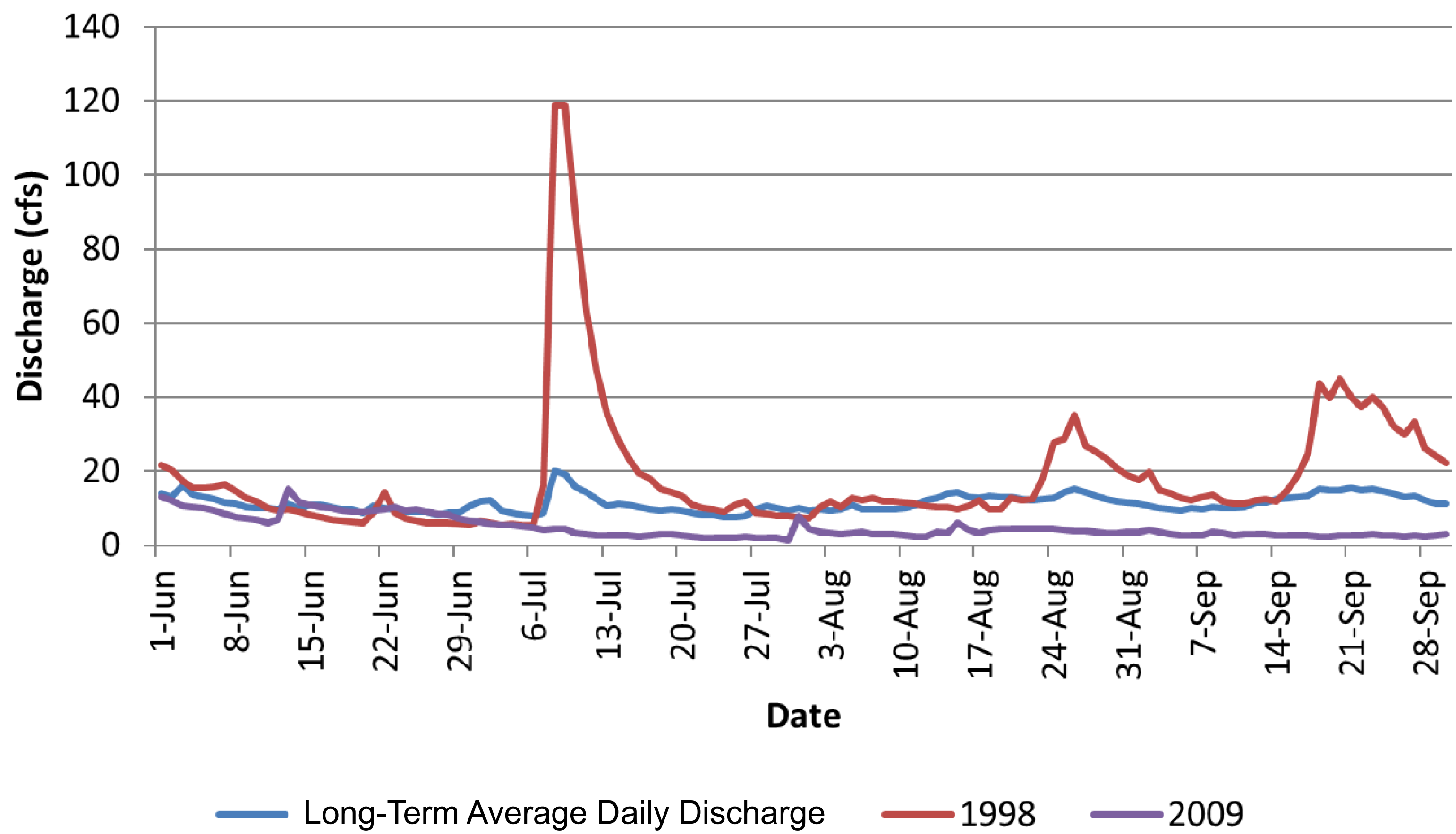
Year	1996	1997	1998	1999	2000	2002	2005	2006	2007	2008	2009	2011	Avg.
June average discharge (cfs)	NA	NA	10.5	NA	7.1	NA	NA	12.1	NA	NA	9.4	NA	**9.8**
July average discharge (cfs)	NA	NA	24.4	15.6	5.8	7.1	6.0	9.9	13.3	NA	3.3	6.2	**10.2**
August average discharge (cfs)	20.6	3.1	15.1	12.1	14.9	7.7	4.7	19.6	14.1	5.9	3.6	18.9	**11.7**
September average discharge (cfs)	10.9	5.0	23.3	12.3	16.8	19.0	16.4	12.4	14.9	5.1	2.8	8.7	**12.3**
October average discharge (cfs)	NA	NA	NA	NA	NA	16.8	NA	NA	NA	6.7	9.2	NA	**10.9**

Notes:
NA = not available
Source: BGC 2012a.

Periodic manual measurements were collected between 2005 and 2010 at two locations in upper American Creek, above and below the proposed WRF (Stations ACAW and ACBW, respectively; Figure 3.5-2). Station ACAW is also located at the proposed Upper Contact Water Dam site, and represents water flow that would be contained in the Contact Water Pond (Figure 2.3-6 in Chapter 2, Alternatives). Flow measurements at this location ranged from 0.57 to 3.99 cfs during the open-water season, and from 0 cfs (frozen) to 0.46 cfs in winter (BGC 2012a). Flow measurements at ACBW below the WRF ranged from 2.8 to 22.9 cfs during the open-water season, and from 0 cfs (frozen) to 4.27 cfs in winter (BGC 2012a).

Omega Gulch

Omega Gulch is a small tributary of Crooked Creek located upstream from Anaconda Creek (Figure 3.5-2). Various project facilities such as the truckshop / warehouse and power plant would be located on low ridges above Omega Gulch. The Omega Gulch drainage area is 0.9 square miles. Only one discharge measurement has been made in Omega Gulch, in June 2005, at a flow rate of 1.3 cfs (BGC 2012a).



Data Sources: BGC 2012a, Donlin Gold 2013

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AMERICAN CREEK AVERAGE DAILY DISCHARGE AT STATION AMER

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FIGURE 3.5-3

Anaconda Creek

Stream flow data were collected on Anaconda Creek (Figure 3.5-2), during the open-water season, between 2002 and 2010. The gauging station (named ANDA) is located upstream from the confluence with Crooked Creek and downstream of the proposed TSF and other infrastructure. The channel at the gauging station is approximately 6.5 to 8 feet wide, and the drainage area is 7.6 square miles (BGC 2012a). The long-term average daily discharge for open-water monitoring season is presented on Figure 3.5-4. In addition to the long-term average, the average daily discharge from 2003, 2005, and 2006 is also included on Figure 3.5-4 to show seasonal variability during the monitoring period. The minimum average daily recorded discharge occurred in mid-August 2005 and was approximately 2 cfs. The maximum average daily recorded discharge occurred in early July 2003 and was approximately 78 cfs. The 2006 hydrograph shows the peak discharge occurring in mid-August, a function of a late summer rainfall event. Due to river ice conditions in the winter and early spring, limited discharge data are available for Anaconda Creek during periods other than the open-water season. However, one discharge measurement was taken each year in early December between 2006 and 2010, with the discharge ranging from 1.3 to 3.5 cfs. In 2006, there was no flow recorded due to ice in the channel.

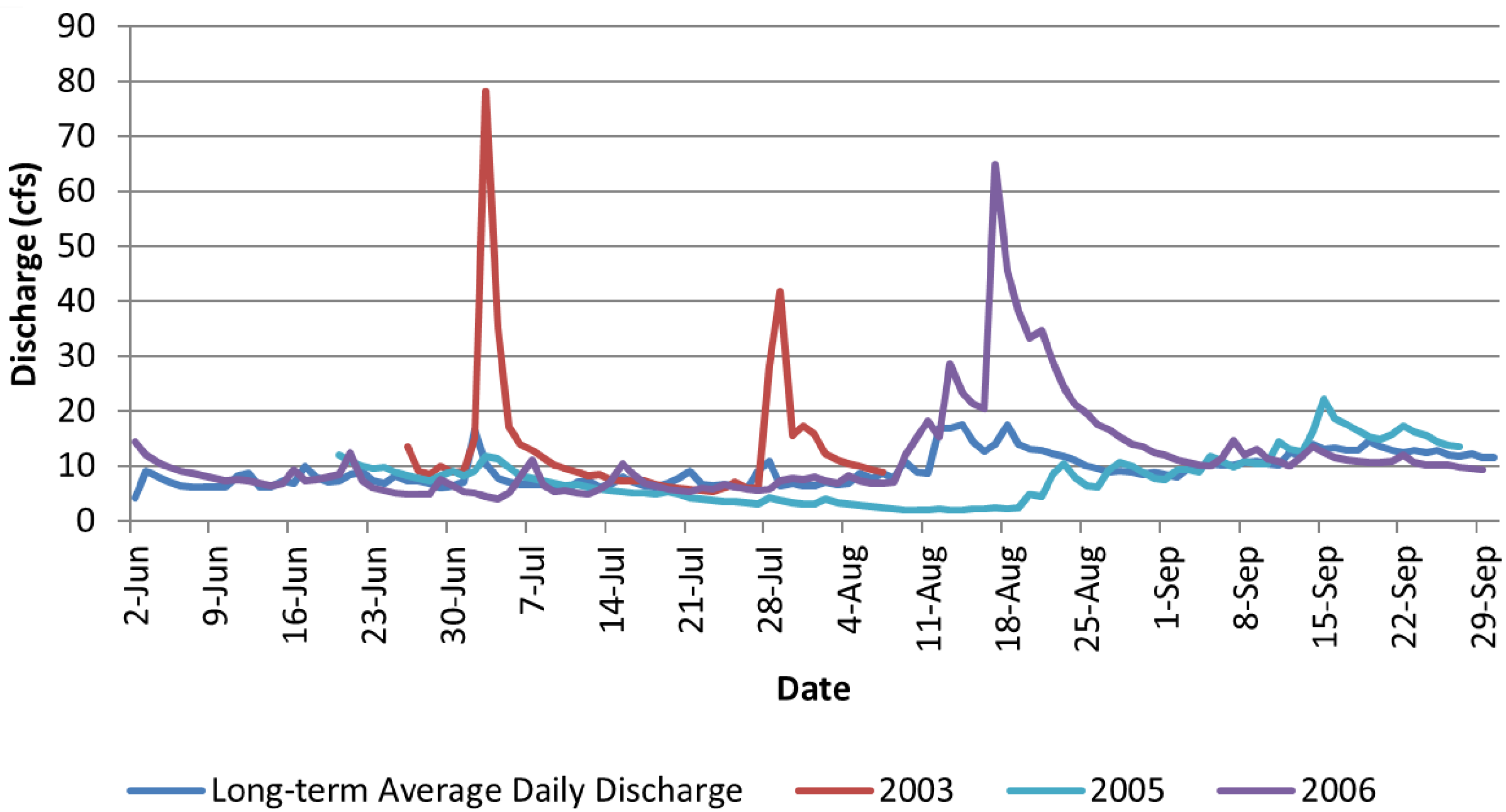
Average monthly discharge in Anaconda Creek between June and September is listed in Table 3.5-6. As shown in the table, the average monthly discharge ranges from 2.1 cfs to 21.6 cfs. The variability of seasonal discharge in Anaconda Creek is similar to that of Crooked Creek, and is a function of precipitation event timing, duration and intensity, and existing soil moisture conditions.

Table 3.5-6: Anaconda Creek Average Monthly Discharge at Station ANDA

Year	2002	2003	2005	2006	2007	2008	2009	2010	2011	Average
June avg. discharge (cfs)	NA	NA	NA	NA	NA	NA	NA	5.5	**NA**	**5.5**
July avg. discharge (cfs)	5.1	14.1	6.0	6.3	9.4	5.2	2.1	6.3	**5.2**	**6.6**
August avg. discharge (cfs)	5.2	NA	4.4	19.6	9.5	6.0	3.1	14.9	**21.6**	**10.5**
September avg. discharge (cfs)	18.7	NA	13.4	11.3	13.4	8.9	3.3	19.3	**8.8**	**12.1**

Notes:
NA = Not Available
avg. = average
Source: BGC 2012a.

Periodic manual measurements were collected between 2005 and 2010 in upper Anaconda Creek drainage (ANUP) Station (Figure 3.5-2). ANUP is located above the upstream end of the proposed TSF footprint at year 5 of operations, and below the North Fresh Water Diversion Dam (SRK 2012b). This station represents water that would need to be diverted or contained by a starter impoundment at the location of the proposed tailings dam prior to its full build-out after year 5 of operations. Flow measurements at this location ranged from 0.81 to 7.13 cfs during the open-water season, and from 0 cfs (frozen) to 0.2 cfs in winter (BGC 2012a).



Data Sources: BGC 2012a, Donlin Gold 2013

DONLIN GOLD PROJECT EIS

ANACONDA CREEK AVERAGE DAILY DISCHARGE AT STATION ANDA

NOVEMBER 2015

FIGURE 3.5-4

Crevice Creek

Stream flow data were collected on Crevice Creek (Figure 3.5-2) during the open-water season between 2009 and 2010. The Crevice Creek watershed, while not within the proposed mine development footprint, would receive water from a freshwater reservoir during mine closure. The gauging station (named CRDN) is located approximately 1,000 feet upstream from the confluence with Crooked Creek. At the gauging station, the channel is approximately 6.6 feet wide, and the drainage area is 7 square miles (BGC 2012a). Average daily discharge for the two years of monitoring is presented on Figure 3.5-5. The hydrographs show that the average daily discharge in 2010 was substantially higher in August and September than the same period in 2009, the difference being related to more fall precipitation in 2010 than 2009. For the 2-year period of record, the minimum recorded mean daily discharge was approximately 2 cfs and the maximum was just over 32 cfs. Due to river ice conditions in the winter and early spring, limited discharge data are available for Crevice Creek during periods other than the open-water season. However, one discharge measurement was taken each year in early December between 2009 and 2010, with the discharge ranging from 0.3 cfs to 6.6 cfs.

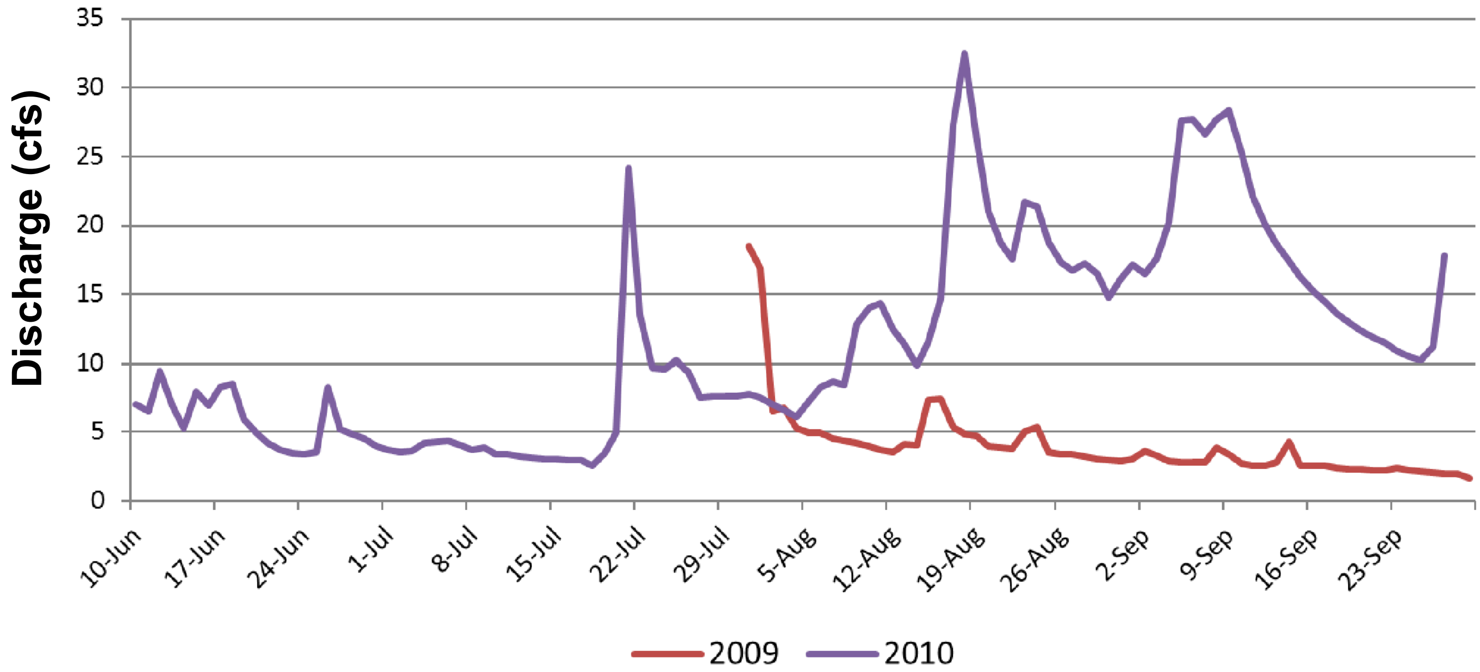
Average monthly discharge in Crevice Creek between June and September is listed in Table 3.5-7. Although this is a limited data set, the data provide an indication of monthly discharge characteristics during the open-water season. As shown in Table 3.5-7 average monthly discharge ranges from 2.7 to 26.4 cfs for the period of record (BGC 2012a).

Table 3.5-7: Crevice Creek Average Monthly Discharge at Station CRDN

Year	2009	2010
June average discharge (cfs)	NA	NA
July average discharge (cfs)	NA	4.4
August average discharge (cfs)	4.9	14.1
September average discharge (cfs)	2.7	26.4

Notes:
NA – Not Available
Source: BGC 2012a.

Periodic manual measurements were collected between 2005 and 2010 in upper Crevice Creek at Station CRUP, located about half-way between the proposed location of the post-closure TSF runoff pond and the confluence with Crooked Creek (Figure 3.5-2). Flow measurements at this location ranged from 1.9 to 17.4 cfs during the open-water season and from 0.4 to 1.4 cfs in winter (BGC 2012a).



Data Sources: BGC (2012a), Donlin Gold (2013)

DONLIN GOLD
PROJECT EIS

CREVICE CREEK AVERAGE DAILY DISCHARGE AT STATION CRDN

NOVEMBER 2015

FIGURE 3.5-5

Crooked Creek

Crooked Creek flow data has been collected during open-water seasons at various locations in the vicinity of the proposed mine site (Figure 3.5-2). The primary gauging station on Crooked Creek (named CCAC) is located approximately 490 feet upstream from the Crevice Creek confluence, and represents flow conditions immediately downstream from the southern end of the proposed mine development. The channel is approximately 49 feet wide at the location of the gauging station, and the drainage area is 112 square miles (BGC 2012a). The long-term average daily discharge for each day of the open-water monitoring period is presented on Figure 3.5-6. In addition to the long-term average, the average daily discharge from 2005 and 2006 is included to show seasonal variability during the monitoring period. The minimum average daily discharge was recorded in mid-August 2005 and was approximately 37 cfs. The maximum average daily discharge was approximately 880 cfs, recorded in late August 2006. Due to river ice conditions in the winter and early spring months, limited discharge data are available for periods beyond the open-water season. However, one discharge measurement was taken each year in early December between 2006 and 2010, with discharge ranging from 16 cfs to 32 cfs.

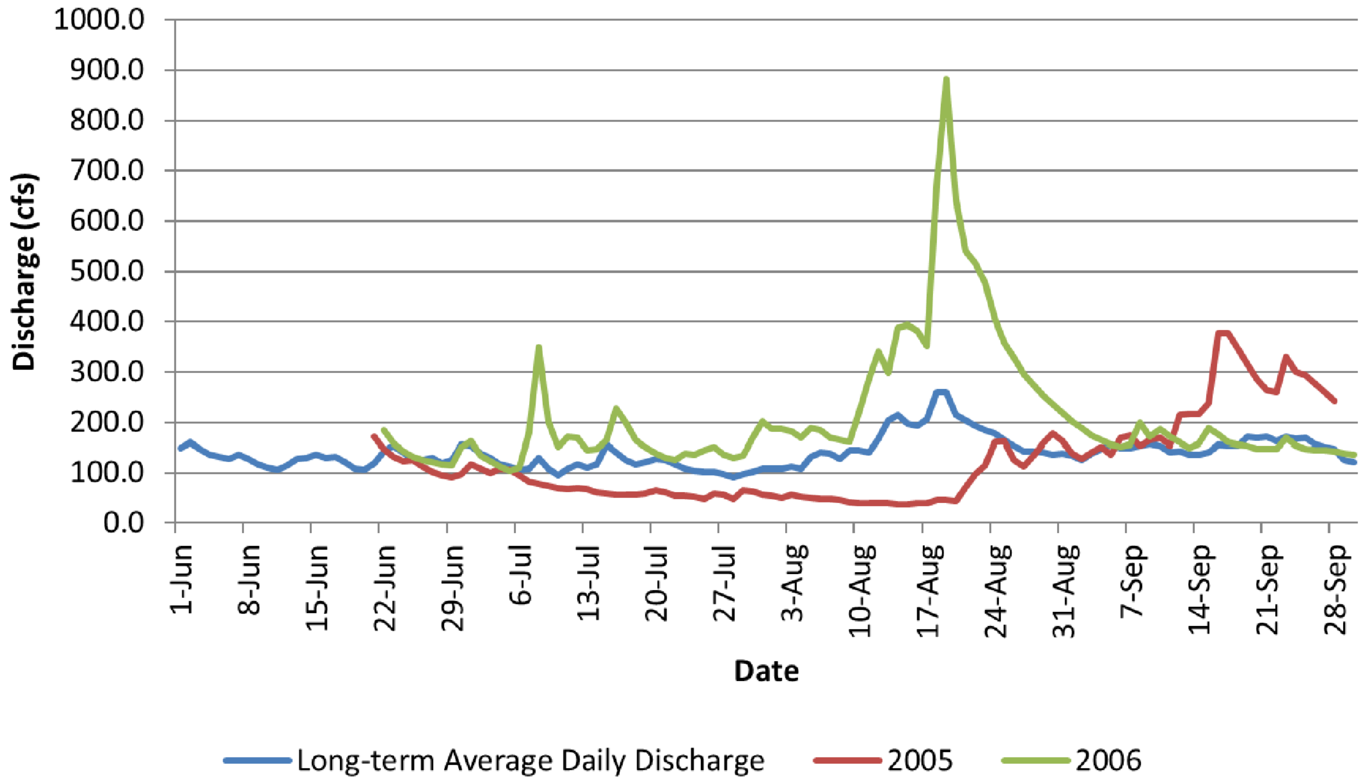
Average monthly discharge between June and October (Table 3.5-8) ranges from 54 to 334 cfs. The stream flow variability from year to year is a function of complex processes that influence runoff in the Crooked Creek watershed. These include, but are not limited to, the timing of precipitation events, precipitation duration and intensity, and existing soil moisture conditions.

Table 3.5-8: Average Monthly Discharge in Crooked Creek at Station CCAC

Year	2005	2006	2007	2008	2009	2010	2011	Average
June average discharge (cfs)	NA	NA	NA	183.7	124.2	109.1	96.5	**128.4**
July average discharge (cfs)	69.7	158.1	204.3	147.8	67.3	86.9	74.7	**115.5**
August average discharge (cfs)	76.4	334.4	177.8	69.0	67.0	226.7	227.8	**168.4**
September average discharge (cfs)	232.2	163.0	227.5	67.7	56.1	230.6	101.9	**154.1**
October average discharge (cfs)	NA	NA	NA	54.8	98.3	NA	NA	**76.6**

Source: BGC 2012a.

Periodic manual flow measurements have been collected in lower Crooked Creek. At Station CCAK near the confluence with the Kuskokwim River, open-water season measurements collected in 2008-2010 ranged from 134.7 to 428.4 cfs, and winter measurements in 2007-2010 ranged from 9.5 to 104.8 cfs (BGC 2012a). A single flow measurement at Station CCBB, located about 3 miles upstream of the mouth of Crooked Creek, was 210 cfs in late June 2013 (Enos 2013b).



Data Sources: BGC 2012a, Donlin Gold 2013

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CROOKED CREEK AVERAGE DAILY DISCHARGE AT STATION CCAC

NOVEMBER 2015

FIGURE 3.5-6

The interaction between Crooked Creek groundwater and stream flow in the vicinity of the proposed mine site is of particular interest due to the mine pit dewatering that would occur during mine operations. An initial assessment of monitoring well water level data suggest that the stream reach in the vicinity of the proposed open pit (American Creek) is a gaining reach (BGC 2013b); that is, flow is being increased by groundwater inflow.

Lower Crooked Creek - USGS Gauging Station

The USGS installed a stream gauging station (#15304010) on Crooked Creek in July 2007, located approximately 10 miles downstream from CCAC (Figure 3.5-2). The drainage area at the USGS gauging station is approximately 327 square miles. Average monthly discharge for the period of record (July 2007 through December 2013) at the USGS gauging station on Crooked Creek are presented in Table 3.5-9, and a summary of peak discharge is presented in Table 3.5-10.

Table 3.5-9: Summary of Average Monthly Discharge on Crooked Creek (USGS)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	63	54	49	47	1,778	822	640	238	234	180	78	56
2009	48	43	40	491	1,559	498	232	231	184	285	62	39
2010	24	20	19	35	769	412	320	703	609	200	132	96
2011	57	43	34	59	825	368	263	1,098	389	219	103	67
2012	47	39	36	691	1,531	901	506	621	1,430	669	159	80
2013	59	44	32	33	1,261	625	554	486	895	NA	NA	NA
Mean of Monthly Discharge	50	40	35	226	1,290	604	445	569	644	357	133	72
2007	NA	NA	NA	NA	NA	NA	601	603	768	588	266	93

Source: USGS 2013b

Table 3.5-10: Summary of Peak Discharge on Lower Crooked Creek (USGS)

Date	Peak Discharge (cfs)
May 13, 2008	6,150
May 02, 2009	3,000[1,2]
May 11, 2010	2,000[1,2]
Aug. 13, 2011	3,960
Sep. 23, 2012	3,930
May 26, 2013	4,240[3]

Notes:
1 Discharge is a Maximum Daily Average
2 Discharge is an Estimate
3 Discharge due to Snowmelt, Ice-Jam or Debris Dam breakup

Source: USGS 2013b.

As shown in Table 3.5-10, peak discharge typically occurs during spring break-up. However, in 2011 and 2012, the peak discharge occurred in August and September, respectively. This indicates that peak discharges can occur during the summer and fall months in any given year, as roughly 65 percent of the average precipitation falls between June and September (BGC 2011f).

The USGS Crooked Creek measurements provide an independent data set for comparing streamflow measurements taken upstream adjacent to the proposed mine. Runoff depths at the USGS gauging station on Crooked Creek and from American Creek are shown in Table 3.5-11. Runoff depth is equal to the runoff volume from a drainage basin divided by the drainage area. For the concurrent measurement period, the total runoff observed at Crooked Creek was 13.7 inches, compared to 13.8 inches at American Creek. The similar runoff depths indicate a strong level of confidence with the site measurements (BGC 2011f).

Table 3.5-11: Crooked Creek (USGS) versus American Creek Runoff Depth (2007 – 2009)

Year	Period	Crooked Creek USGS (inches)	American Creek (Inches)
2007	July 1 – October 6	7.45	7.83
2008	August 16 – October 9	1.46	1.69
2009	May 31 – October 17	4.75	4.28
Total		13.66	13.80

Source: BGC 2011f.

3.5.2.1.3 METEOROLOGICAL INPUTS TO WATER BALANCE MODELING

Donlin Gold's water management plan is the basis for developing fresh water requirements and supply for mine process water, appropriate design of water management and treatment systems, and minimizing the potential for uncontrolled discharges of untreated contact or tailings water. Water balance models were developed for the proposed mine and used to evaluate various scenarios in order to develop a water management plan. Table 3.5-12 lists the meteorological parameter inputs and the applicable water balance models. Section 3.26, Climate Change provides further discussion of meteorological and climate data for the proposed mine site.

Table 3.5-12: Meteorological Data Inputs for Water Balance Models

Parameter	Data Inputs Used For
Precipitation	Site water balance, unsaturated groundwater flow modeling[1], groundwater modeling of pit slope depressurization, and pit lake hydrology following mine closure.
Temperature (average, maximum and minimum daily)	Unsaturated flow and pit lake models
Solar Radiation	Unsaturated flow and pit lake geochemical models for internal calculations of evaporation
Wind Speed	Unsaturated flow and pit lake geochemical model for internal calculations of evaporation

Table 3.5-12: Meteorological Data Inputs for Water Balance Models

Parameter	Data Inputs Used For
Relative Humidity (average, maximum and minimum)	Unsaturated flow and pit lake geochemical model for internal calculations of evaporation
Evaporation and Sublimation	Site water balance, unsaturated flow model, and pit lake geochemical model

Notes:

1 Unsaturated flow modeling was used to evaluate flow through the unsaturated vadose zone into groundwater, ground infiltration due to rainfall, and potential evaporation.

Source: BGC 2011f.

Precipitation Data

Precipitation data are an important input to the water balance model. Precipitation data were collected at various sites within the proposed Project Area between 1996 and the present, specifically at: the Camp Station from 2004 to present; the American Ridge Station between 1996 and 2000; and the Snow Ridge site between 1997 and 2000 (Figure 3.5-7). Nearby regional meteorological stations with long-term precipitation data are located at McGrath (1939-present), Crooked Creek (1911–1974, intermittent), Aniak (1920–1990, intermittent), Flat (1936–1961), and Sleetmute (November 1993–present) (Figure 3.5-7).

Based on a review of all datasets, and on comparisons between the proposed mine site and regional datasets, the data from long-term regional stations at McGrath and Crooked Creek, combined with the Camp Site data from both Camp Station and American Ridge (collectively referred to as Camp Site Stations), provided the best dataset for developing a synthetic long-term precipitation record from which to estimate precipitation at Donlin Creek (BGC 2011f). Regional analysis of precipitation data included correlation between Camp Site Stations data and McGrath data for the 1996–2000 and 2004–2010 period of record at the Camp Site Stations. Precipitation at the Camp Site Stations was approximately 17 percent higher than precipitation measured at McGrath (BGC 2011f).

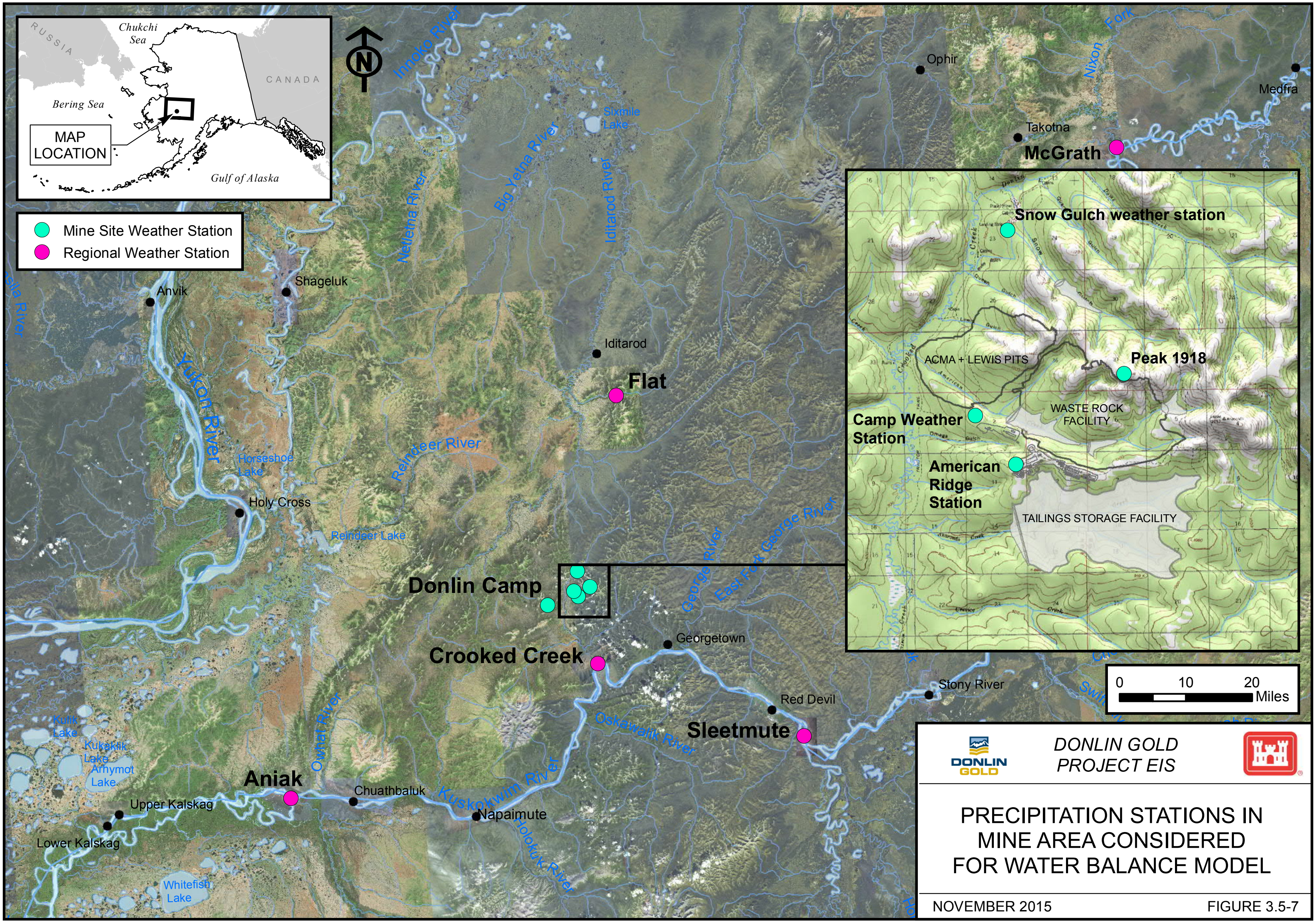
The average precipitation at the Crooked Creek station was the preferred data set to use as the scaled proxy for developing a synthetic precipitation dataset because it is closer to the proposed mine site than the station at McGrath. Additionally, McGrath precipitation data would not account for natural climate variability, which is characterized by short time periods when observed annual precipitation between the sites showed poor correlation (BGC 2011f). A 100-year synthetic precipitation dataset (weekly and daily) was generated for Crooked Creek using industry standard statistical software (Crystal Ball®). Generating this dataset was necessary due to the fragmented precipitation record at Crooked Creek (BGC 2011f). The precipitation data was divided into weeks, probability distribution functions were generated for each week according to best-fit distribution, and a correlation matrix was generated between each of the weeks. Probability distribution functions were generated for each week according to the best-fit distribution using the Anderson-Darling method as a goodness-of-fit test. The best-fit distributions included Gamma, Beta, maximum extreme, minimum extreme, and Weibull (BGC 2011f). Crystal Ball® uses the correlation matrix in combination with the probability distribution functions to generate the synthetic datasets, an approach that is considered statistically more realistic (BGC 2011f). The result is a 71-year synthetic Crooked Creek dataset for the period 1940-2010. Using the synthetic dataset, average precipitation at Crooked Creek is calculated to be 14.8 inches, with a majority of the precipitation occurring in the summer months. Using a scaling factor of 1.33, the average annual precipitation at Donlin Creek is calculated to be 19.6 inches (BGC 2011f). Estimated monthly precipitation levels are listed in Table 3.26-1 (refer to Chapter 3.26, Climate Change).

Snowmelt

Snowmelt is used in the site water balance, and is calculated in both the unsaturated flow and pit lake models. Snowpack survey data from 2007, 2008, and 2010 from American and Anaconda Creek watersheds, and snowmelt start and end dates from the McGrath climate station, were used to estimate snowmelt runoff volume for the mine water balance (BGC 2011f). Due to the limited snow survey data collected in prior years (1996 - 2003) at the proposed mine site, the 2007, 2008, and 2010 data were considered more comprehensive (up to 61 sample locations and multiple sample events each year) and representative of both American and Anaconda creeks' watersheds for the purposes of water balance modeling (BGC 2011f). The McGrath climate station includes snow on ground data since 1942, and the start of snowmelt was established using the McGrath maximum temperature data for a 1942 to 2010 period of record. On average, snowmelt starts April 3 and ends May 3 for a total of 31 days. These snowmelt start and end dates, as well as actual snowmelt rates at McGrath, were used for the site water balance, based on the assumption that snowmelt rates at McGrath would be representative of conditions at American and Anaconda Creek watersheds, as temperature and solar radiation are not likely to be notably different between the sites (BGC 2011f).

Comparison of snow water equivalent (SWE) from snow course data collected in 2007, 2008 and 2010, with winter precipitation measured at Camp Station during the same times, indicated that winter precipitation was being dramatically under-reported by the Camp Station automatic precipitation gauge (BGC 2011f, 2013e). The under-reporting of winter precipitation is likely due to the Camp Station being located on a ridge between the American and Anaconda Creek watersheds, and the effect of wind limiting the capacity of the gauge to collect snow (BGC 2011f). Therefore, to establish total precipitation for each month of the year presented in Table 3.26-1, Climate Change, precipitation during winter months at the mine was estimated by comparing McGrath precipitation measurements with SWE measured at the proposed mine site. Precipitation measurements at McGrath were found to be more consistent with snowpack survey SWE data from the proposed mine. Precipitation at the proposed site mine was approximately 17 percent greater than precipitation recorded at McGrath, which was consistent with the regional analysis of precipitation between the Camp Site Stations and McGrath (BGC 2011f).

The resulting monthly precipitation levels from rainfall and snowfall estimated for the proposed mine site based on the 100-year synthetic dataset are listed in Table 3.26-1, Climate Change. The total annual precipitation based on this analysis is 19.63 inches, including 13.58 inches of annual rainfall plus 6.05 inches of annual snowfall.



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PRECIPITATION STATIONS IN MINE AREA CONSIDERED FOR WATER BALANCE MODEL

NOVEMBER 2015

FIGURE 3.5-7

The effect of wind-blown snow on water balance at the mine was evaluated by BGC (2013d). Site wind speed records indicate that the prevalent winter snow transport direction is from the southeast to east-southeast. Based on an approach used for snow transport management (e.g., snow fence design), the potential annual blown snow entering the proposed open pit was estimated to be less than 1.5 percent of the annual water-equivalent volume for an average snowfall year. This estimate was based on the following data and assumptions: 1) that snow would only be transported when wind speeds exceed a threshold of 12.1 mph, which would occur about 20 percent of the time; 2) that there would be no sublimation or other losses; and 3) that the proposed pit would capture all snow blown towards it, ignoring potential capture by waste rock pile slopes above the pit.

Other Meteorological Data

Meteorological data have been collected at various locations throughout the proposed mine site, including: Snow Ridge (November 1995 – 2000); American Ridge (September 1999 – October 2001, December 2002 – June 2013); Camp Site Station (October 2005 – August 2014); and Hill 1918 (April 2007 – March 2011).Data collected include temperature, radiation, wind speed, relative humidity, evaporation, and sublimation (BGC 2011f).

While temperature data have been collected at the proposed mine site stations, the McGrath temperature data were selected for use in the mine water balance models. The McGrath period of record for temperature is from 1941 to 2010, which covers greater climate variability relative to the proposed mine site dataset. Synthetic datasets for a period of 1940 to 2010 were also generated for solar radiation, wind speed, and relative humidity using Crystal Ball® (BGC 2011f). The development of these parameter datasets is discussed in Section 3.26, Climate Change, and the monthly values used for the various mine site models are presented in Table 3.26-1.

Water Balance Calibration

The majority of the proposed mine infrastructure lies within the American Creek and Anaconda Creek watersheds. Therefore, calibration of the mine water balance model was conducted using the discharge measurements taken in American and Anaconda creeks (BGC 2011f). The most suitable calibration periods for the water balance model were considered to be 1996–2000 and 2005–2010, because precipitation was recorded at the Camp Site Stations during these time periods, and because discharge measurements were taken concurrently in American Creek (during both periods) and Anaconda Creeks (only during 2005 – 2010). As discussed in the Section 3.5.2.1.2, the discharge record is generally limited to the open-water season.

After consideration of the calibration dataset and review of a number of different water balance models, a model by Vandewiele et al. (1992) was selected for estimating the site water balance on a monthly and weekly basis, because of its successful and accurate application in a variety of climactic settings, including northern latitudes (BGC 2011f). This model is spreadsheet-based, divides runoff into slow and fast components that approximate groundwater and surface water flows, and is sophisticated enough to adequately represent complexities of the proposed mine construction and operation phases. Good calibration and validation was obtained with this model, and the weekly time-frame allowed for higher intensity, shorter-duration runoff events to be captured in water balance predictions (BGC 2011f). Calibration results for American Creek and Anaconda Creek water balance models are presented in Table 3.5-13.

Table 3.5-13: Water Balance Calibration Results

American Creek Calibration 1996 to 2000			
Year	**Period**	**Modeled Runoff (inches)**	**Observed Runoff (inches)**
1996	July 24 – October 7	6.3	5.9
1997	July 24 – September 30	2.4	2.1
1998	May 24 – September 30	11.6	13.8
1999	June 16 – September 30	9.5	8.3
2000	June 8 – September 23	6.2	6.9
Total		36.0	37.0
Anaconda Creek Calibration 2005 to 2010			
2005	June 24 – September 23	3.9	3.4
2006	June 8 – October 15	6.7	6.4
2007	July 1 – October 7	7.5	6.3
2008	August 16 – October 7	1.5	1.8
2009	August 1 – September 30	1.2	1.2
2010	June 1 – September 23	5	6
Total		25.3	25.5

Source: BGC 2011f.

3.5.2.1.4 FLOOD MAGNITUDE AND FREQUENCY

Flood magnitude and frequency for each watershed within the proposed mine area were estimated using USGS regression equations developed for Alaska (Curran et al. 2003), and are summarized in Table 3.5-14. Estimates for the 100-year flood event, for example, range from 76 to 84 cfs for small tributaries such as Omega Gulch, 229 to 438 cfs for larger tributaries such as American and Anaconda creeks, and 3,536 cfs for Crooked Creek at Station CCAC. Natural hazards associated with flooding include higher than normal velocities in the channel that can increase bank erosion and alter channel patterns.

Table 3.5-14: Flood Magnitude and Frequency for Proposed Mine Site Watersheds

	Return Period						
	2	**5**	**10**	**25**	**50**	**100**	**200**
Avg Standard Error of Prediction (%)	41	42	45	48	52	55	58
Avg Equivalent Years of Record (yrs)	1.8	2.5	3.2	3.9	4.3	4.6	4.8

Table 3.5-14: Flood Magnitude and Frequency for Proposed Mine Site Watersheds

Watershed	Discharge (cfs)						
Crevice Creek	78	143	197	275	341	411	486
Anaconda Creek	84	154	211	294	363	438	518
Unnamed Creek (SE1)	10	20	29	43	55	69	83
Omega Gulch	12	25	36	53	68	84	101
American Creek	73	135	185	260	321	388	460
Lewis Gulch	11	23	33	48	62	76	92
Queen Gulch	12	25	36	53	68	84	101
Snow Gulch	40	76	106	151	188	229	273
Crooked Creek (at CCAC)	924	1503	1942	2549	3031	3536	4063

Notes:
With exception of CCAC, estimates are for whole watershed area at confluence with Crooked Creek.
Source: Discharge estimated based on Curran et al. (2003) regression equations and USGS (2013a) topographic data.

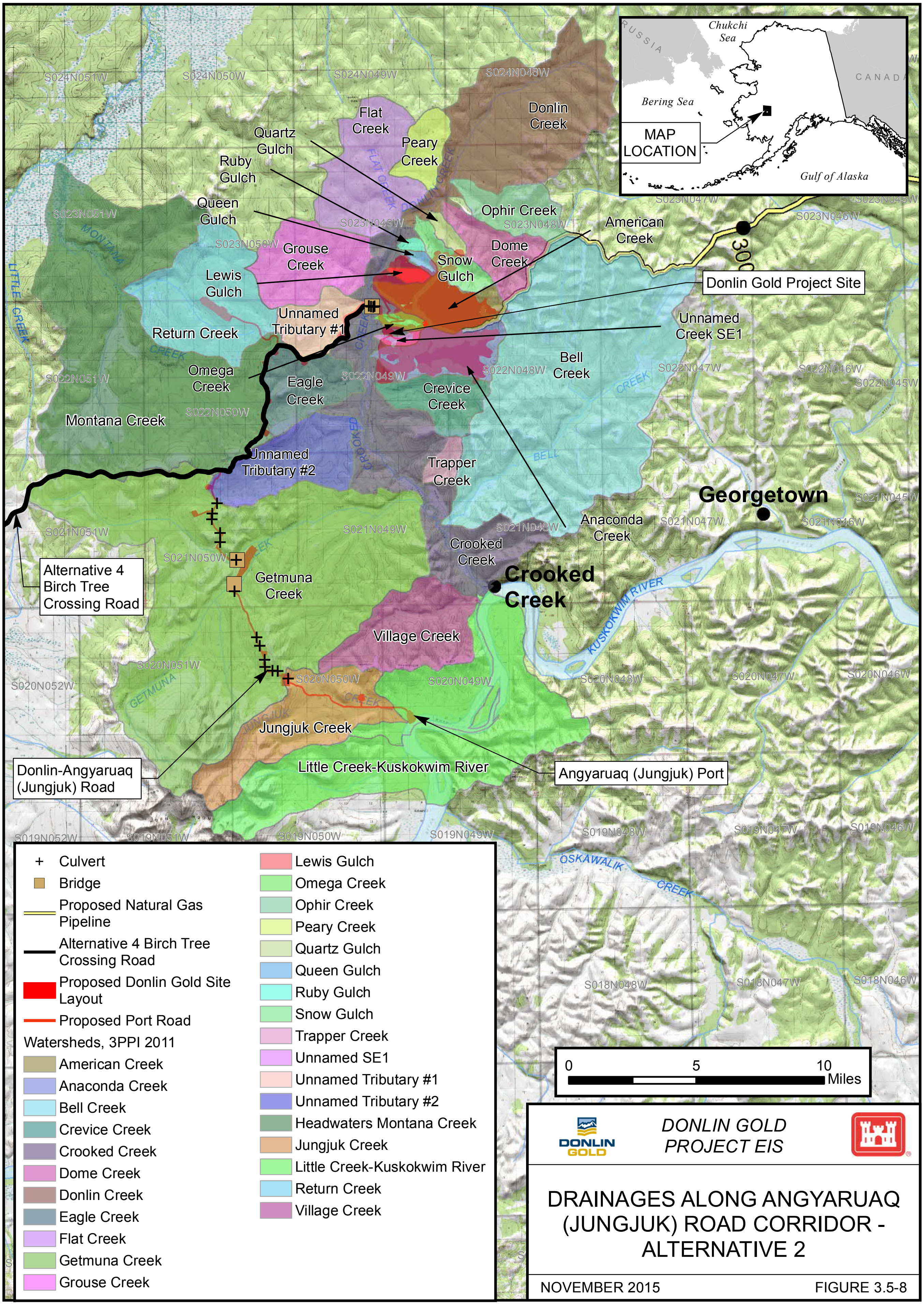
3.5.2.1.5 SURFACE WATER USE

Existing domestic water supply at the mine site and village of Crooked Creek is from groundwater wells (Section 3.6, Surface Water Hydrology). Surface water rights in Crooked Creek near the mine site were applied for by Lyman Resources in Alaska, Inc., a former placer mine owner. These water rights were never issued and the site is listed in the ADNR (2013e) database as "permit pending action." Under the conditions of the lease agreement between Donlin Gold and the Lymans, all water rights were assigned to Donlin Gold. There are no existing instream flow reservations in the Crooked Creek watershed. Donlin Gold holds a Temporary Water Use Authorization (TWUA) at the mine site (main camp area) in Section 2 of T22N/R49W issued in 2012, and has applications pending for additional TWUAs in sections east and south of the main camp area.

3.5.2.2 TRANSPORTATION FACILITIES

3.5.2.2.1 ANGYARUAQ (JUNGJUK) ROAD CORRIDOR

The proposed Angyaruaq (Jungjuk) road corridor is approximately 30 miles long, ending at the proposed Angyaruaq (Jungjuk) Port on the Kuskokwim River (Figure 3.5-8). The road would be used to transport cargo and fuel from Angyaruaq (Jungjuk) Port to the mine site. There would be 51 stream or drainage crossings along the proposed route, 6 of which would require bridges; the rest would require culverts (SRK 2013a). Jungjuk Creek, Getmuna Creek, and Unnamed Tributary #2 are considered anadromous (see Section 3.13.2.2.1, Fish and Aquatic Resources). Stream crossing data, including stream width and depth, as well as the type of proposed crossing (bridge or culvert) are presented in Table 1, Appendix G. The mine road corridor includes a short spur road for access to the proposed airstrip.



DRAINAGES ALONG ANGYARUAQ (JUNGJUK) ROAD CORRIDOR - ALTERNATIVE 2

NOVEMBER 2015 FIGURE 3.5-8

Drainage Basins/Watersheds

The proposed Angyaruaq (Jungjuk) Road would traverse seven watersheds between the proposed mine site and Angyaruaq (Jungjuk) Port, listed in Table 3.5-15. With the exception of Jungjuk Creek and Montana Creek, all watersheds traversed by the road are tributaries of Crooked Creek, and are located on the west side of Crooked Creek.

Table 3.5-15: Watersheds Traversed by the Proposed Angyaruaq (Jungjuk) Road Corridor

Drainage Basin	Drainage Area (square miles)	Channel Length (miles)	Basin Relief (feet)	Mean Basin Elevation (feet)
Crooked Creek	93.0	23.2	331 to 2,130	883
Unnamed Tributary #1	5.8	4.1	335 to 1,151	764
Eagle Creek	8.5	4.9	298 to 797	718
Montana Creek	68	21.3	271 to 1,925	687
Unnamed Tributary #2	12.6	6.6	272 to 1,824	653
Getmuna Creek	98.6	23.1	192 to 3,610	938
Jungjuk Creek	17.4	10.1	137 to 3,472	1,092

Notes:
Watershed data presented here is that portion of Crooked Creek above the proposed mine access road crossing
Source: Calculated in AutoCad Civil 3D based on USGS 2013a; NHD 2012; Arcadis 2012a.

Crooked Creek Crossing

The proposed Angyaruaq (Jungjuk) Road would cross Crooked Creek between American Creek and Omega Gulch (Figure 3.5-1 and Figure 3.5-8). It is estimated that the bridge span at this location would be approximately 84 feet (SRK 2013b). The Crooked Creek drainage area above the proposed road crossing is 93 square miles.

Unnamed Tributary #1

After the Crooked Creek crossing, the proposed route crosses Unnamed Tributary #1 near the Crooked Creek confluence (Figure 3.5-1 and Figure 3.5-8). The Unnamed Tributary #1 watershed covers 5.8 square miles and ranges in elevation from 335 feet to 1,151 feet, with a total basin relief of approximately 816 feet and mean basin elevation of 764 feet. The main channel length is approximately 4.1 miles. The proposed route then follows the southern watershed boundary of Unnamed Tributary #1 to the proposed site of the main camp facility. The camp, located at road mile 2.4 (measured from the beginning of the road at the mine site), would be constructed on a ridge between Unnamed Tributary #1 and two smaller tributaries of Crooked Creek. The proposed road route continues in a westerly direction along the southern watershed boundary of Unnamed Tributary #1 and Eagle Creek, turning south at the western end of Unnamed Tributary #1.

Eagle Creek

The Eagle Creek watershed covers 8.5 square miles and ranges in elevation from 298 feet to 797 feet, with a total basin relief of approximately 488 feet and mean basin elevation of 718 feet. The main channel length is approximately 4.9 miles. The route does not cross Eagle Creek or any major tributaries within the Eagle Creek drainage; it traverses the northern watershed boundary with Unnamed Tributary #1 and the western boundary with Montana Creek (Figure 3.5-1 and Figure 3.5-8).

Montana Creek

Montana Creek is a tributary of the Iditarod River, which drains northwest to the Yukon River. The Montana Creek watershed covers 68 square miles and ranges in elevation from 271 feet to 1,925 feet, with a total basin relief of approximately 1,654 feet and mean basin elevation of 687 feet. The main channel length is approximately 21 miles. Montana Creek is a highly sinuous stream with channel bed material consisting of gravel and sand sized material. At road mile 5.4 of the proposed Angyaruaq (Jungjuk) Road, a 3-mile long spur road would be constructed for access to the project airstrip. The spur road and airstrip would be located in the Montana Creek watershed (Figure 3.5-1 and Figure 3.5-8). The proposed airstrip would be a 5,000-foot long by 150-foot wide gravel-surfaced runway, and would be constructed on a ridge (SRK 2013a). The Angyaruaq (Jungjuk) Road would continue south from the spur road, traversing the eastern Montana Creek watershed boundary with Eagle Creek and Unnamed Tributary #2. The proposed Angyaruaq (Jungjuk) Road, airstrip spur road, and airstrip do not cross Montana Creek or tributaries within the watershed.

Unnamed Tributary #2

Unnamed Tributary #2 is a small tributary of Crooked Creek, south of Eagle Creek (Figure 3.5-1 and Figure 3.5-8). The Unnamed Tributary #2 watershed covers 12.6 square miles and ranges in elevation from 272 feet to 1,824 feet, with a total basin relief of approximately 1,552 feet and mean basin elevation of 653 feet. The main channel length is approximately 6.6 miles. The proposed Angyaruaq (Jungjuk) Road route traverses a small portion of the northern and western boundaries of the watershed, and does not cross any streams within the Unnamed Tributary #2 watershed.

Getmuna Creek

The proposed Angyaruaq (Jungjuk) Road would enter the Getmuna Creek watershed near the north-central portion of the northern watershed boundary (Figure 3.5-1 and Figure 3.5-8). Getmuna Creek, one of the larger Crooked Creek tributaries, has a watershed area of 98.6 square miles The Getmuna Creek watershed ranges in elevation from 192 feet to 3,610 feet, with a mean basin elevation of 938 feet. The main channel length is approximately 23 miles. The access road would traverse the central portion of the Getmuna Creek watershed, crossing as many as 14 tributary streams that would require the installation of culverts. Additionally, both the north and south fork channels of Getmuna Creek would require bridge crossings, each with approximately 65-foot spans (SRK 2013a).

Jungjuk Creek

The proposed Angyaruaq (Jungjuk) Road would exit the southeast boundary of the Getmuna Creek watershed, traversing the Jungjuk Creek watershed in an east-southeast direction (Figure 3.5-1 and Figure 3.5-8). Jungjuk Creek is a tributary to the Kuskokwim River and is characterized by moderate sinuosity with gravel and cobble substrate (OtterTail Environmental Inc. 2007). The Jungjuk Creek watershed covers 17.4 square miles and ranges in elevation from 137 feet to 3,472 feet, with a mean basin elevation of 1,092 feet. The main channel length is approximately 10 miles. The road would cross many tributary channels of Jungjuk Creek, requiring the installation of culverts. Two stream crossings, the north and south fork of Jungjuk Creek, would each require a 29-foot bridge crossing (SRK 2013a).

<u>Stream Flow</u>

Limited stream flow data exists for the drainages along the proposed Angyaruaq (Jungjuk) Road alignment. Discharge estimates made during road alignment surveys at stream crossings by RECON (2011b) are presented in Table 1, Appendix G. The design flow for culvert dimensions and bridge construction requirements will be determined during the final design phase of the project. Additional discharge data presented below were collected in the lower portion of the watersheds, near their confluence with Crooked Creek.

Eagle Creek

Discharge measurements during open-water conditions were made in Eagle Creek in 2009 and 2010, several miles below the proposed road location and upstream from the confluence with Crooked Creek. The minimum and maximum discharges during the monitoring period are listed in Table 3.5-16. Discharge measurements were also taken during the winter and ranged from zero (frozen) to 3.4 cfs (BGC 2012a).

Table 3.5-16: Eagle Creek Minimum and Maximum Discharge

Date	Minimum Discharge (cfs)	Date	Maximum Discharge (cfs)
9/30/2009	3.6	6/26/2009	11.9
7/16/2010	4.1	8/20/2010	20.3

Note:
Data for open-water season only.
Source: BGC 2012a.

Unnamed Creek #1

Several small drainages in the headwaters of Unnamed Tributary #1, located between mileposts (MP) 13 and 14, are estimated to have typical flows of 1 cfs or less (RECON 2011b) (Table 1, Appendix G). These are incised channels within boggy and alder settings with evidence of aufeis (sheet-like, layered mass of ice formed by successive flows of groundwater in freezing conditions).

Getmuna Creek

Typical flows in the North and South forks of Getmuna Creek at the proposed bridge locations were estimated to be 40 and 65 cfs, respectively (RECON 2011b). A tributary to South Fork Getmuna Creek that would require a third bridge is estimated to have a typical flow of 10 cfs. A number of small channels that would be crossed in the Getmuna watershed are estimated to have typical flows of 1 cfs or less.

Discharge measurements made on Getmuna Creek during the 2013 open-water season, about 8 miles below the proposed road crossings and borrow material site, and just upstream from the confluence with Crooked Creek (Figure 3.5-2) are listed in Table 3.5-17 (Enos 2013b). Flow at this location ranged from 101 to 241 cfs. The average depth of the channel at the location where the discharge measurements were made was 1.6 feet and the average channel width was 41 feet.

Table 3.5-17: Getmuna Creek 2013 Discharge

Date	Discharge (cfs)
6/12/2013	241.3
7/12/2013	195.0
8/3/2013	101.4
8/7/2013	204.8
9/2/2013	176.2

Source: Enos 2013b.

Flood Magnitude and Frequency

Flood magnitude and frequency for each watershed crossed by the proposed mine access road were estimated using USGS regression equations developed for Alaska (Curran et al. 2003). These are summarized in Table 3.5-18. With the exception of Crooked Creek, the estimates are for the whole watershed area at the confluence with Crooked Creek, or in the case of Montana and Jungjuk creeks, their confluences with the Iditarod and Kuskokwim rivers, respectively. Estimates for Crooked Creek represent the watershed area above the proposed bridge crossing.

Estimates for the 100-year flood event, for example, range from 355 to 648 cfs for mid-size streams such as Eagle and Jungjuk creeks and the unnamed tributaries, to a range of 2,400 to 3,203 cfs for the larger streams such as Montana and Getmuna creeks and Crooked Creek above the proposed bridge crossing. Hazards associated with flooding include higher than normal velocities in the channel that can increase bank erosion and alter channel patterns.

Table 3.5-18: Flood Magnitude and Frequency for Watersheds Traversed by Proposed Angyaruaq (Jungjuk) Road

Watershed	Return Period						
	2	5	10	25	50	100	200
	Discharge (cfs)						
Crooked Creek	783	1,284	1,666	2,196	2,618	3,061	3,524
Unnamed Tributary #1	66	122	169	237	294	355	421
Eagle Creek	92	169	231	322	397	478	564
Montana Creek	592	985	1,287	1,708	2,045	2,400	2,773
Unnamed Tributary #2	131	236	320	441	541	648	763
Getmuna Creek	825	1,349	1,748	2,301	2,741	3,203	3,685
Jungjuk Creek	130	233	316	436	534	640	754

Notes:
Crooked Creek drainage area used for this calculation is that portion above the proposed mine access road crossing.
The average standard error of prediction and average equivalent years of record for each return period are the same as those listed in Table 3.5-13.

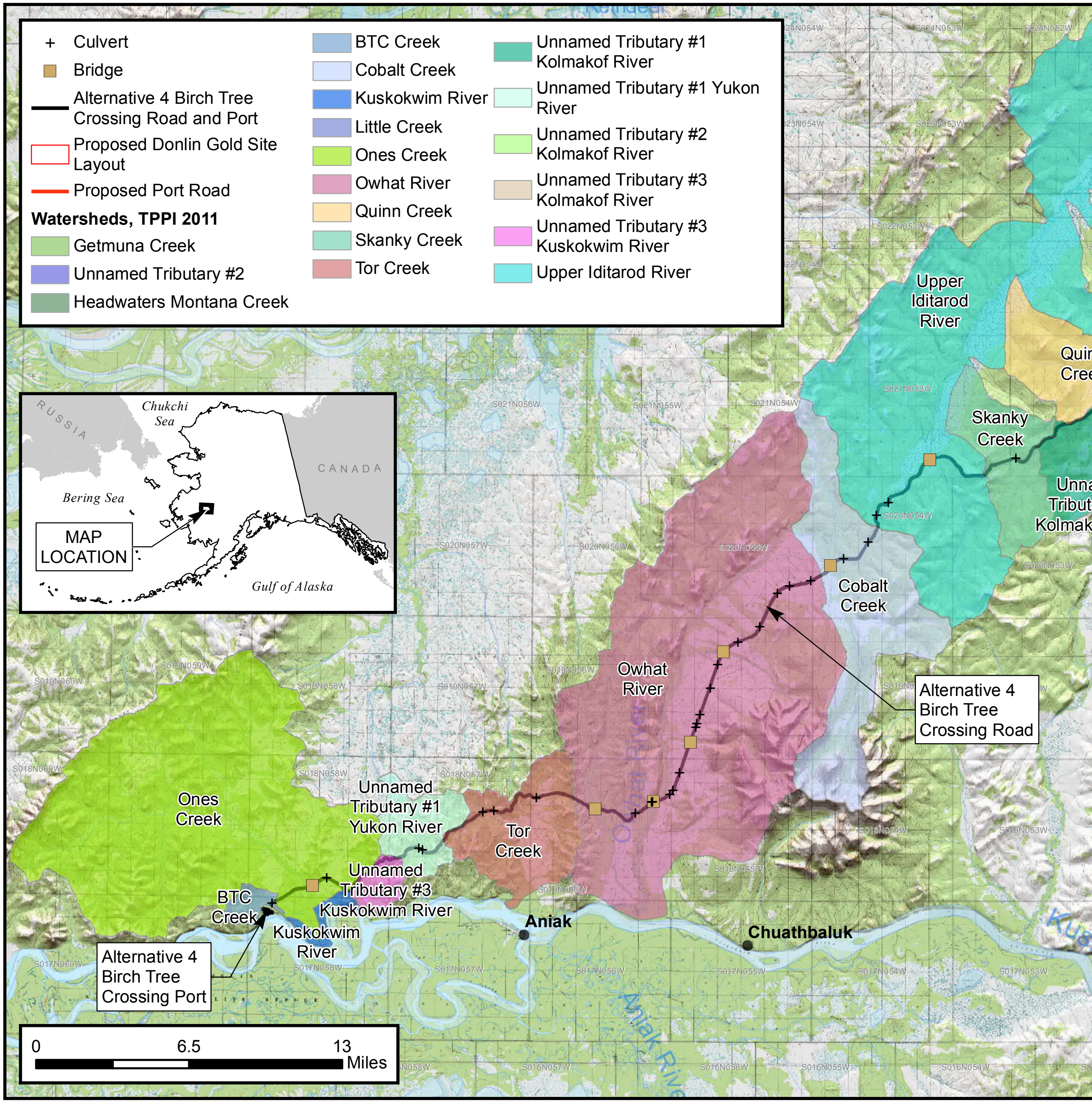
Source: Discharge estimated based on Curran et al. (2003) regression equations and USGS (2013a) topographic data.

3.5.2.2.2 BIRCH TREE CROSSING ROAD CORRIDOR – ALTERNATIVE 4

The Birch Tree Crossing (BTC) mine access road (Alternative 4) is approximately 76 miles long, starting at the proposed BTC Port on the Kuskokwim River and ending at the mine site (Figure 3.5-9. The BTC road would follow the Angyaruaq (Jungjuk) Road alignment from the upper (western) ridge of Unnamed Tributary #2 to Crooked Creek (Figure 3.5-9). Those watersheds are described in Section 3.5.2.2.1, and the watersheds between the BTC Port and Unnamed Tributary #2 are described below. The BTC road would cross 40 streams, 5 of which are anadromous. Eight of the stream crossings would require bridges and 32 would require culverts. Stream crossing data, including stream width and depth, as well as the type of proposed crossing (bridge or culvert) are presented in Table 2, Appendix G.

Drainage Basins/Watersheds

Drainage basins traversed by the BTC Road alignment between the BTC Port and the Angyaruaq (Jungjuk) Road corridor are presented Table 3.5-19. Watersheds including Little Creek, Quinn Creek, Iditarod River, and an unnamed tributary of the Yukon River, are tributaries of the Yukon River. The remaining watersheds traversed by the BTC road alignment are tributaries of the Kuskokwim River (Figure 3.5-9).



DONLIN GOLD

DONLIN GOLD PROJECT EIS

DRAINAGES ALONG BIRCH TREE CROSSING ROAD CORRIDOR - ALTERNATIVE 4

NOVEMBER 2015

FIGURE 3.5-9

Table 3.5-19: Watersheds Traversed by the BTC Road Alignment

Drainage Basin	Drainage Area (square miles)	Main Channel Length (miles)	Basin Relief (feet)	Mean Basin Elevation (feet)
Little Creek	19	12	289 – 1,567	749
Quinn Creek	25	11	338 – 1,524	718
Unnamed Tributary #3 Kolmakof River	6	3	497 – 1,020	745
Unnamed Tributary #2 Kolmakof River	4	4	485 - 982	692
Unnamed Tributary #1 Kolmakof River	18	5	398 – 1,151	642
Skanky Creek	19	10	394 – 1,203	676
Upper Iditarod River	148	53	275 – 2,390	664
Cobalt Creek	45	17	433 – 3,292	1,025
Owhat River	200	41	59 – 3,299	696
Tor Creek	22	10	53 - 957	334
Unnamed Tributary #1 Yukon River	11	5	151 - 710	307
Unnamed Tributary #3 Kuskokwim River	4	3	86 - 658	288
Ones Creek	112	26	44 – 1,953	340
BTC Creek	3	3	61 - 712	274

Little Creek and Quinn Creek

Traveling west/southwest from the Angyaruaq (Jungjuk) Road corridor, the BTC Road would follow the ridge line between Montana Creek and Getmuna Creek watersheds to the southern ridge of Little Creek (Figure 3.5-9). Montana Creek and Getmuna Creek watersheds are discussed in Section 3.5.2.2.1. The BTC Road would traverse only a small portion of the Little Creek watershed, and the route does not cross Little Creek or any major tributaries within the Little Creek drainage. Little Creek is a tributary of the Iditarod River, and has a watershed area of approximately 18.5 square miles (Table 3.5-19).

Continuing west/southwest, the BTC road would remain on a ridge line between Quinn Creek and upper tributaries of the Kolmakof River. Quinn Creek is a tributary of the Iditarod River, and has a watershed area of approximately 24.5 square miles (Table 3.5-19). The route does not cross Quinn Creek or any major tributaries within the Quinn Creek drainage.

Kolmakof River Tributaries

The BTC route would cross the upper portion of three unnamed tributaries of the Kolmakof River along the ridge between Quinn Creek and Kolmakof River watersheds (Figure 3.5-9). Kolmakof River is a tributary of the Kuskokwim River. Unnamed tributary #3, #2, and #1 have drainage areas of 5.8, 4.3, and 18.2 square miles, respectively (Table 3.5-19). The route does not cross these tributary streams or any major tributaries within the Kolmakof River drainage.

Skanky Creek and Upper Iditarod River

The BTC route would cross the Skanky Creek drainage, which is a small tributary of the Iditarod River (Figure 3.5-9). Skanky Creek covers approximately 19 square miles (Table 3.5-19), and the BTC Road would cross Skanky Creek near the middle of the drainage. West of Skanky Creek, the BTC Road traverses the southern portion of the upper Iditarod River drainage, which covers approximately 148 square miles (Table 3.5-19). The route crosses the mainstem of the upper Iditarod River and two small tributaries (each less than 2 square miles) west of the mainstem (Table 2, Appendix G).

Cobalt Creek

The Cobalt Creek watershed covers approximately 45 square miles (Table 3.5-19), and is a tributary of the Owhat River (Figure 3.5-9). The route would cross two small tributaries (each less than 4 square miles) prior to crossing the mainstem of Cobalt Creek (Table 2, Appendix G). The Cobalt Creek headwaters originate along the northern slopes of the Russian Mountains.

Owhat River

The Owhat River watershed covers approximately 200 square miles (Table 3.5-19), and is a tributary of the Kuskokwim River (Figure 3.5-9). The BTC route crosses 15 small tributaries of the Owhat River before crossing the mainstem. The drainage areas of the tributaries at the road crossing range from 0.4 to 8.5 square miles (Table 2, Appendix G). West of the Owhat River crossing, the route crosses two tributaries before exiting the Owhat River watershed, one covers an area 1.8 square miles above the road and the other covers an area approximately 18 square miles above the road (Table 2, Appendix G).

Tor Creek

The BTC Road traverses the northern portion of the Tor Creek watershed, located west of the Owhat River watershed. The Tor Creek watershed covers approximately 22 square miles and is a tributary of the Kuskokwim River (Table 3.5-19 and Figure 3.5-9). After crossing the mainstem of Tor Creek, the route crosses 2 small tributaries of Tor Creek (each draining less than one square mile above the road) (Table 2, Appendix G).

Unnamed Tributary #1 Yukon River

The BTC Road traverses the Unnamed Tributary #1 Yukon River watershed, located west of the Tor Creek watershed. The Unnamed Tributary #1 Yukon River drainage covers approximately 10.5 square miles and is a small headwater tributary of the Yukon River (Table 3.5-19 and Figure 3.5-9). After crossing the mainstem of Unnamed Tributary #1 Yukon River, the route crosses one small tributary of Unnamed Tributary #1 Yukon River, draining less than one square mile above the road (Table 2, Appendix G).

Unnamed Tributary #3 Kuskokwim River, Ones Creek, and BTC Creek

The BTC road follows the ridge that divides Unnamed Tributary #3 and Ones Creek, and does not cross any drainages within the unnamed Tributary Creek #3 watershed (Figure 3.5-9). Unnamed Tributary Creek #3 covers approximately 3.7 square miles, and Ones Creek covers approximately 112 square miles (Table 3.5-19). The route then traverses the southeastern portion of Ones Creek, crossing a small tributary of Ones Creek with a watershed area that covers approximately 7.4 square miles (Table 2, Appendix G). The BTC Road crosses the lower portion of Ones Creek near the end of the route. The area above the Ones Creek crossing is approximately 102 square miles (Table 2, Appendix G). The final drainage traversed along the route is BTC Creek watershed which covers approximately 2.5 acres (Table 3.5-19).

Stream Flow

Stream flow data from streams crossed along the BTC Road alignment is limited to select discharge estimates made during road alignment surveys at stream crossings by RECON (2007c). Stream width, depth, bank material observations, and crossing type (culvert versus bridge) are presented in Table 2, Appendix G. No other stream flow data are currently available on streams along the BTC route. The design flow for culvert dimensions and bridge construction requirements would be determined during the final design phase of the project, if the BTC Road alignment alternative is selected for mine access.

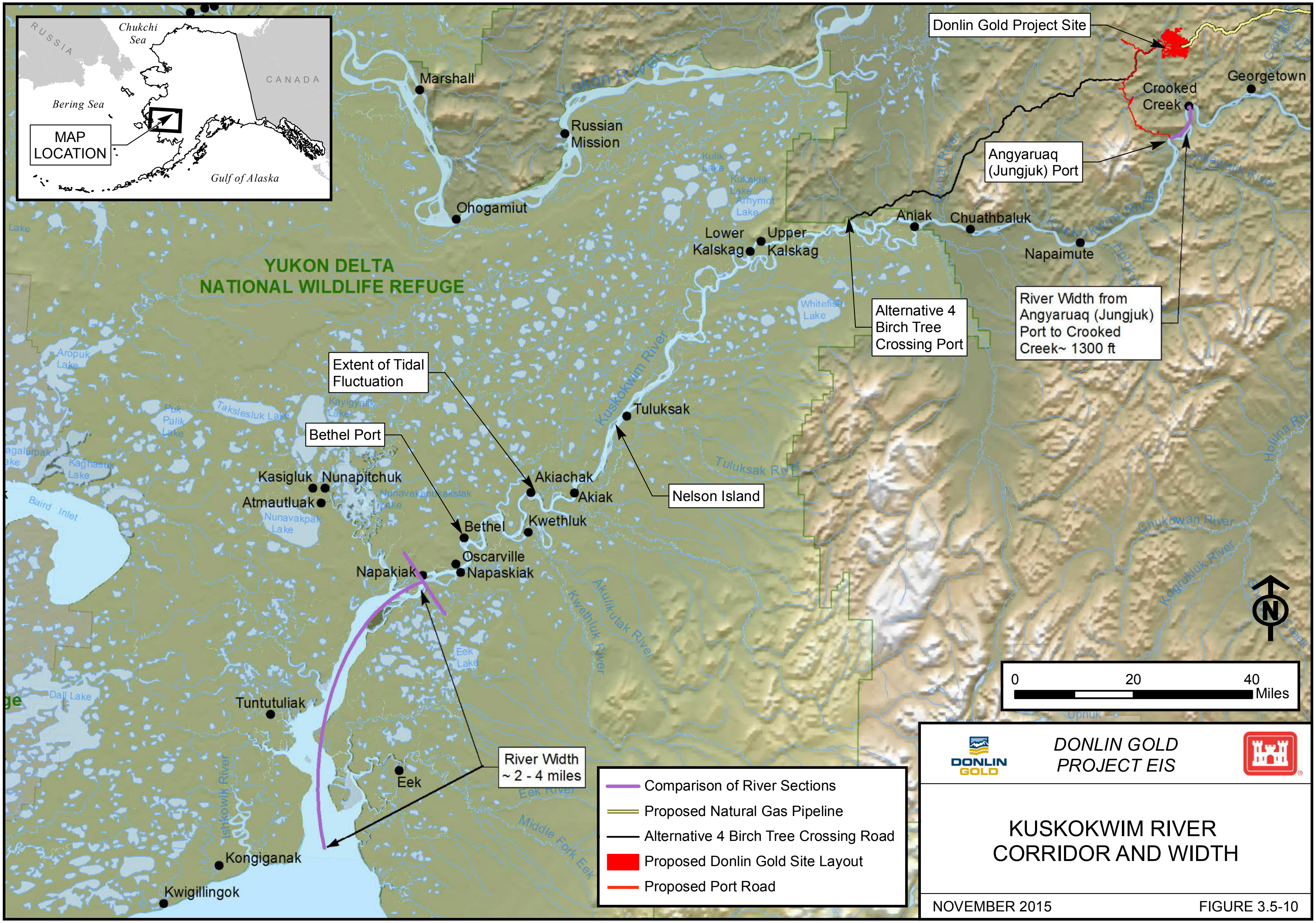
3.5.2.2.3 KUSKOKWIM RIVER AND PORTS

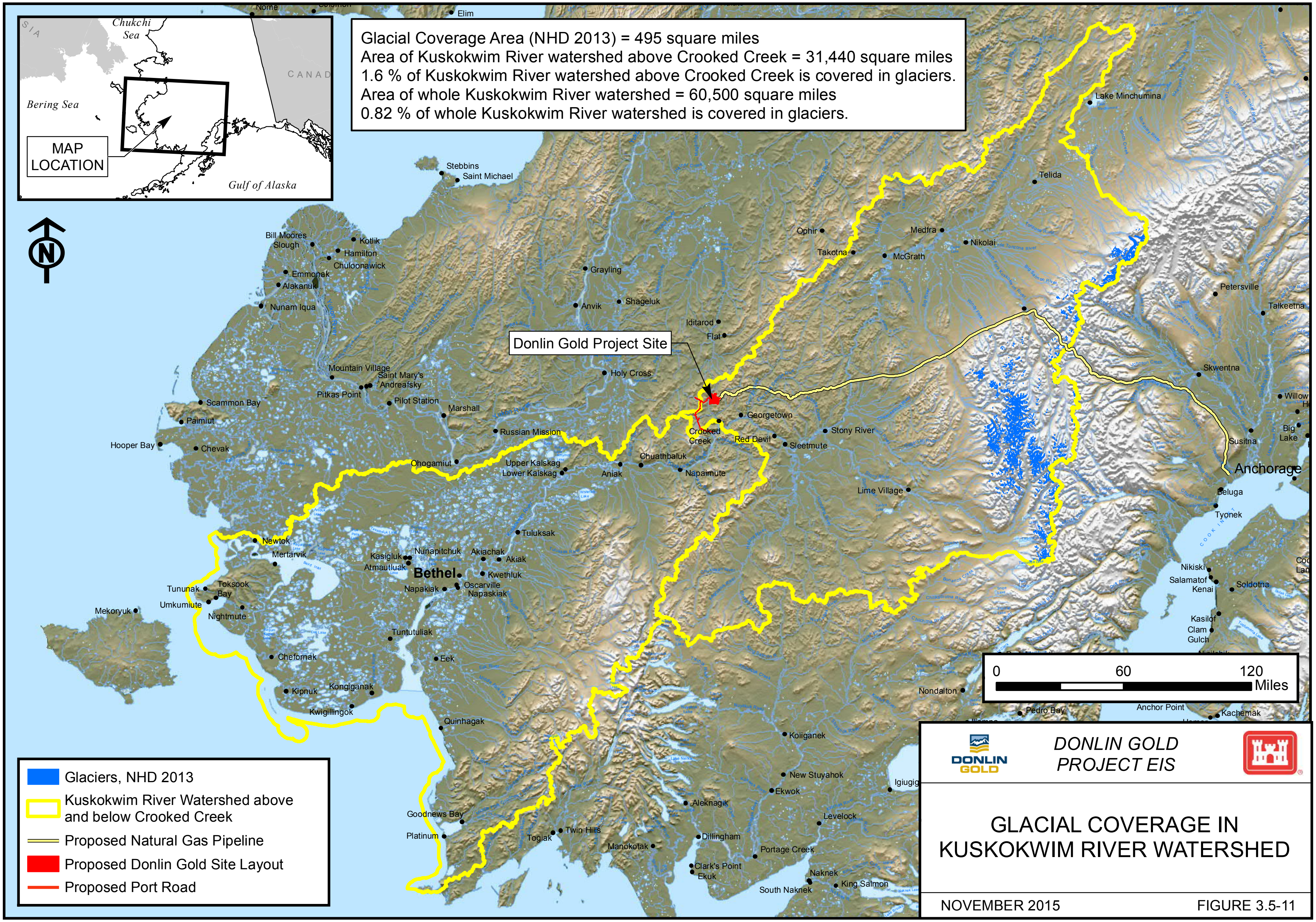
The Donlin Gold Project would require transportation of cargo and fuel up the Kuskokwim River, from the river's mouth to a river port (Figure 3.5-10). General cargo for mine construction and operations would be transported from terminals in Seattle, Vancouver, or Dutch Harbor by ocean barges across the Bering Sea and up the Kuskokwim River to a cargo terminal in Bethel. At Bethel, cargo would be off-loaded for temporary storage and transport upriver (SRK 2013a). Ocean barges from the Bering Sea can only access Bethel during the ice-free season, which is typically between late May and October. Upstream from Bethel, the river is typically ice-free two weeks before the ice is clear at the mouth. Under these conditions, cargo and fuel stored over winter in Bethel would be barged upriver when the river is ice-free between Bethel and the upriver port.

Drainage Basin/Watershed

The Kuskokwim River watershed has an area of approximately 60,500 square miles, and a river channel length of roughly 700 miles. The headwaters originate in the Alaska Range to the north, east and southeast, and in the Kuskokwim Mountains to the northwest. Figure 3.5-11 shows the Kuskokwim River watershed, including watershed boundaries above and below Crooked Creek, and the area containing glaciers (NHD 2012). Approximately one percent of the entire watershed area contains glaciers. The North, South and East forks of the Kuskokwim River merge upstream from McGrath, together with several smaller tributaries, to form the mainstem of the Kuskokwim River. As the river exits the Kuskokwim Mountains near Aniak, it crosses the Kuskokwim Delta, a broad unconfined floodplain.

The lower river channel, between the mouth of the river and the village of Napakiak, has a width of 2 to 4 miles (Figure 3.5-10). Upstream from Napakiak, the river narrows to a width of approximately 1,300 feet in the vicinity of Crooked Creek, which is approximately 275 river miles upstream from the mouth. This portion of the river is characterized by multiple channels, including oxbow channels and split channels, separated by vegetated and mid-channel bars. These features are indicative of a river actively changing due to lateral migration, bank erosion, and sediment deposition (ARCADIS 2007a).


Donlin Gold Project Site
Georgetown
Crooked Creek
Angyaruaq (Jungjuk) Port
Marshall
Russian Mission
Ohogamiut
Yukon River
Aniak
Chuathbaluk
Napaimute
Lower Kalskag
Upper Kalskag
YUKON DELTA NATIONAL WILDLIFE REFUGE
Alternative 4 Birch Tree Crossing Port
River Width from Angyaruaq (Jungjuk) Port to Crooked Creek~ 1300 ft
Kuskokwim River
Extent of Tidal Fluctuation
Tuluksak
Bethel Port
Nelson Island
Kasigluk
Nunapitchuk
Atmautluak
Akiachak
Akiak
Kwethluk
Bethel
Oscarville
Napakiak
Napaskiak
Tuntutuliak
Eek
River Width ~ 2 - 4 miles
Kongiganak
Kwigillingok
Chukchi Sea
RUSSIA
CANADA
Bering Sea
Gulf of Alaska
MAP LOCATION
0
20
40
Miles
N
Comparison of River Sections
Proposed Natural Gas Pipeline
Alternative 4 Birch Tree Crossing Road
Proposed Donlin Gold Site Layout
Proposed Port Road
DONLIN GOLD
DONLIN GOLD PROJECT EIS
KUSKOKWIM RIVER CORRIDOR AND WIDTH
NOVEMBER 2015
FIGURE 3.5-10


Glacial Coverage Area (NHD 2013) = 495 square miles
Area of Kuskokwim River watershed above Crooked Creek = 31,440 square miles
1.6 % of Kuskokwim River watershed above Crooked Creek is covered in glaciers.
Area of whole Kuskokwim River watershed = 60,500 square miles
0.82 % of whole Kuskokwim River watershed is covered in glaciers.
Chukchi Sea
Bering Sea
CANAD
Gulf of Alaska
MAP LOCATION
N
Donlin Gold Project Site
Nome
Elim
Stebbins
Saint Michael
Bill Moores Slough
Kotlik
Hamilton
Chuloonawick
Emmonak
Alakanuk
Nunam Iqua
Grayling
Anvik
Shageluk
Iditarod
Flat
Ophir
Takotna
McGrath
Medfra
Nikolai
Lake Minchumina
Telida
Petersville
Talkeetna
Skwentna
Willow
Big Lake
Susitna
Anchorage
Beluga
Tyonek
Mountain Village
Saint Mary's
Andreafsky
Pitkas Point
Pilot Station
Marshall
Scammon Bay
Paimiut
Hooper Bay
Chevak
Russian Mission
Holy Cross
Georgetown
Crooked Creek
Red Devil
Sleetmute
Stony River
Chuathbaluk
Aniak
Napaimute
Upper Kalskag
Lower Kalskag
Ohogamiut
Lime Village
Newtok
Mertarvik
Tuluksak
Kasigluk
Nunapitchuk
Akiachak
Akiak
Atmautluak
Bethel
Kwethluk
Napakiak
Oscarville
Napaskiak
Tununak
Toksook Bay
Umkumiute
Nightmute
Mekoryuk
Tuntutuliak
Eek
Chefornak
Kipnuk
Kongiganak
Kwigillingok
Quinhagak
Goodnews Bay
Platinum
Togiak
Twin Hills
Manokotak
Aleknagik
Dillingham
Clark's Point
Ekuk
Koliganek
New Stuyahok
Ekwok
Levelock
Portage Creek
Naknek
King Salmon
South Naknek
Igiugig
Nondalton
Pedro Bay
Anchor Point
Kachemak
Nikiski
Salamatof
Kenai
Soldotna
Kasilof
Clam Gulch
0
60
120
Miles
Glaciers, NHD 2013
Kuskokwim River Watershed above and below Crooked Creek
Proposed Natural Gas Pipeline
Proposed Donlin Gold Site Layout
Proposed Port Road
DONLIN GOLD
DONLIN GOLD PROJECT EIS
GLACIAL COVERAGE IN KUSKOKWIM RIVER WATERSHED
NOVEMBER 2015
FIGURE 3.5-11

Kuskokwim River average discharge, widths, and depths at select locations are summarized in Table 3.5-20. The variables listed in Table 3.5-20 were estimated for use in barge wave height calculations (BGC 2007c). Discharge data from the USGS gauging station at Crooked Creek, and the relationship between discharge, channel width, velocity, and depth were used to calculate the variables at each location. For the proposed barging period of June to mid-September, the average discharge of the Kuskokwim River at Crooked Creek (period of record 1952-2005) is approximately 73,900 cfs. The average discharge was then applied to the downstream locations, adjusting for the increase in drainage area. Velocity was calculated using Manning's equation (BGC 2007c).

Table 3.5-20: Summary of Hydraulic Variables for Sites on the Lower Kuskokwim River

Site	Drainage Area (square miles)	Average Discharge (cfs)	Width (feet)	Average Velocity (feet per second)	Average Depth (feet)
Aniak	35,870	85,220	3,400	2.8	9.1
Kalsag	36,650	87,070	2,740	2.9	10.9
Tuluksak	38,570	91,640	2,885	3.0	10.7
Akiak	39,470	93,760	2,130	3.3	13.2
Akiachak	40,110	95,300	2,110	3.2	14.2

Source: BGC 2007c.

The average gradient between Crooked Creek and the mouth of the Kuskokwim is 0.0086 percent. This low-gradient river is subject to tidal fluctuations upstream to Akiachak, located approximately 30 river miles upstream from Bethel (AGRA 1998). Storm surge[1] is likely to extend further upriver on a high tide. Channel bed material from the mouth to Bethel is predominately sand, silt, and clay. The occurrence of coarser bed material increases from Bethel upstream to the BTC and Angyaruaq (Jungjuk) Port sites, with gravel and cobbles common in the higher-velocity sections of the channel, transitioning to sand, silt, and clay in the shallower, slower moving portions of the channel (Jewett et al. 2010a).

Water depth in the main channel of the Kuskokwim River depends on local weather conditions (AMEC 2014). Under average open-water flow conditions, ocean barges navigate upriver to Bethel and river barges drafting up to 8 feet navigate as far upstream as Crooked Creek. Several locations along the Kuskokwim River have been identified as critical sections upstream of Bethel with respect to channel width constrictions and shallow water depth that affect river barge travel (Table 3.5-21). Bathymetric surveys were conducted in 2007 near the BTC Port site (located approximately 115 river miles upstream from Bethel) and Nelson Island (located upstream from Akiak). At BTC, average depths were 8 to 10 feet; and the maximum water depth in the main channel around Nelson Island was 5.8 feet. The discharge at the time of the 2007 survey was approximate 46,260 cfs at BTC (Terrasond, Ltd. 2007). In 2010, additional

1 Storm surge is an abnormal sudden rise in sea level that accompanies storm winds, and causes water and ice to pile up over low coastlines and into coastal river valleys.

bathymetric surveys were performed along roughly 16 river miles between Aniak and the proposed Angyaruaq (Jungjuk) Port site. The shallowest section of the main navigation channel during the 2010 survey was found just upstream from the village of Aniak, and was 8.4 feet. The corresponding average daily flow at the USGS Crooked Creek gauging station was 63,000 cfs (AMEC 2014).

Additional width and depth data at the critical sections along the Kuskokwim River from the 2007 and 2010 bathymetric surveys are presented in Table 3.5-21. The depths listed in Table 3.5-21 are depths related to under keel clearance at water surface elevations associated with an average daily discharge of 39,000 cfs, and are not the maximum depth below the water surface. Similarly, available channel widths are based on a gross under keel clearance of 2 feet at water surface elevations associated with an average daily discharge of 39,000 cfs (AMEC 2014).

Table 3.5-21: Kuskokwim River Widths and Depths at Critical Sections

Location	Survey Year	Minimum Channel Depth[3] (feet)	ACW (feet)
Nelson Island	2007[1]	5	129
Birch Tree Crossing	2010[2]	5	415
Aniak	2010[2]	5	354
Holokuk	2010[2]	5	576
Upper Oskawalik	2010[2]	5	214

Notes:
1 Terrasond 2007
2 AMEC 2014
3 The minimum channel depth of 5 feet would accommodate a barge tow having 3 feet of draft and a gross under keel clearance of 2 feet at an average daily flow of 39,000 cfs.
ACW = Available Channel Width

Stream Flow

The USGS stream gauging station at Crooked Creek has collected discharge data on the Kuskokwim River since 1952 (USGS 2014b). The drainage area at this location is approximately 31,100 square miles. Seasonal variations in ice conditions affect the length of the barging season in any given year. River barge transportation planning for the project is based on a conservative 110-day shipping window during open-water conditions between early June and early September (AMEC 2014). Average daily discharge at the Crooked Creek gauging station during the open-water season ranges from a minimum of 25,200 cfs, recorded in mid-September 2004, to a maximum of 391,000 cfs, recorded in early June 1964.

Figure 3.5-12 illustrates the average daily discharge on the Kuskokwim River at Crooked Creek for the period of record on each day between June 1st and September 30th (AMEC 2014). In general, spring breakup occurs in May as the ice moves out and the average daily discharge increases. In June, the average daily discharge usually decreases throughout most of the month. In July and August, the average daily discharge varies relatively little, but is usually increasing slightly throughout this period. At the end of August and September, the average daily discharge increases for short periods of time in response to rainfall events. However, the overall trend in September is for the average daily discharge to decrease. The river typically begins to freeze up in early October.

To further illustrate the variability of average daily discharge in any given year, Figure 3.5-12 compares average daily discharge during the open-water seasons of 1964 and 1997, and the average daily discharge for the period of record on each day of the open-water season (AMEC 2014). It is important to note that the latter does not represent the hydrograph for any one year. The average daily discharge peak of record in early June of 1964 was 391,000 cfs, substantially higher than the long-term average daily discharge in early June, which is closer to 100,000 cfs. Conversely, in 1997 the average daily discharge for the entire open-water season was 41,250 cfs (AMEC 2014).

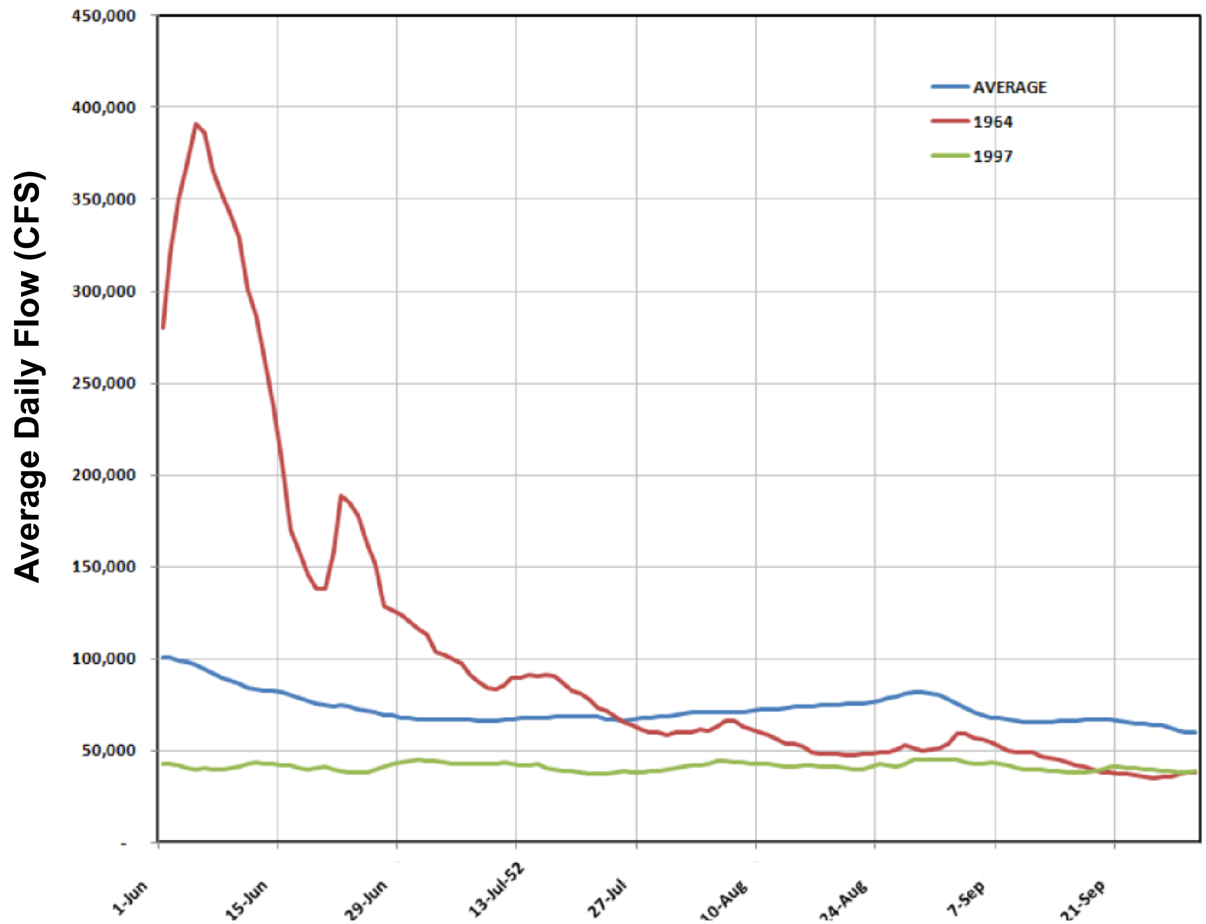
Present day barge operations monitor the daily discharge at Crooked Creek, and typically require the discharge to be 40,000 cfs or higher to navigate between Bethel and Crooked Creek. When the discharge is less than 40,000 cfs, grounding in shallower sections is more likely. Figure 3.5-13 shows the number of days that the average daily discharge was less than 45,000 cfs for the years between 1952 and 2009 (AMEC 2014). Flow rates dropped below this level in 22 of the 58 years of record (37 percent), and were below this level for 20 or more days in 10 of the years (17 percent).

Flooding/Drought Estimates and Hazards

A flood magnitude and frequency analysis performed by Curran et al. (2003) for the Kuskokwim River at Crooked Creek is summarized in Table 3.5-22. For example, the 100-year flood event is reached at a discharge of 349,000 cfs. This level was exceeded once (in early June 1964) in the 58-year period of record for the Kuskokwim River (Figure 3.5-12).

Hazards associated with flooding include debris in the river from increased bank erosion, higher than normal velocities in the main channel, navigational challenges associated with selection of the shipping channel, and possible exposed rocky banks and bottoms in the upper river. Bathymetric surveys conducted in 2007 noted soft sediment banks heavily laden with flood debris in the lower Kuskokwim near Tuluksak, and both rocky banks and sticky deep mud in the proposed BTC Port area, near Aniak (Terrasond 2007).

The average daily discharge during each day of the open-water season in a year with one of the lowest flows on record (1997) is presented on Figure 3.5-12. Low flow volumes in the Kuskokwim River increase the potential for barge grounding.



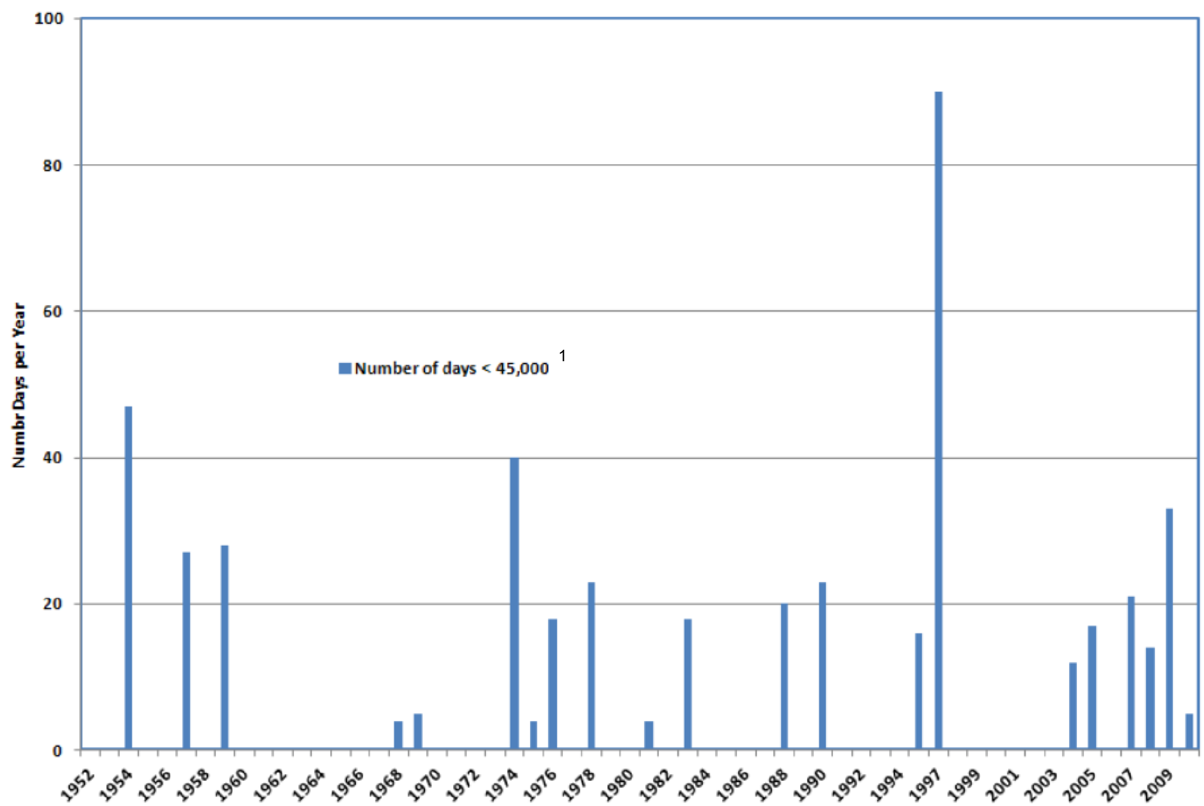
Data Sources: AMEC 2013

DONLIN GOLD
PROJECT EIS

KUSKOKWIM RIVER DISCHARGE AT CROOKED CREEK DURING OPEN-WATER SEASON

NOVEMBER 2015

FIGURE 3.5-12



DONLIN GOLD
PROJECT EIS

NUMBER OF DAYS AVERAGE DAILY DISCHARGE < 45,000 CFS AT CROOKED CREEK

NOVEMBER 2015

FIGURE 3.5-13

Data Sources: AMEC 2013

1. Average on annual basis

Table 3.5-22: Kuskokwim River Flood Magnitude and Frequency at USGS Crooked Creek Gauging Station

Recurrence Interval	Discharge (cfs)
2-year	163,000
5-year	217,000
10-year	250,000
25-year	291,000
50-year	321,000
100-year	349,000
200-year	377,000

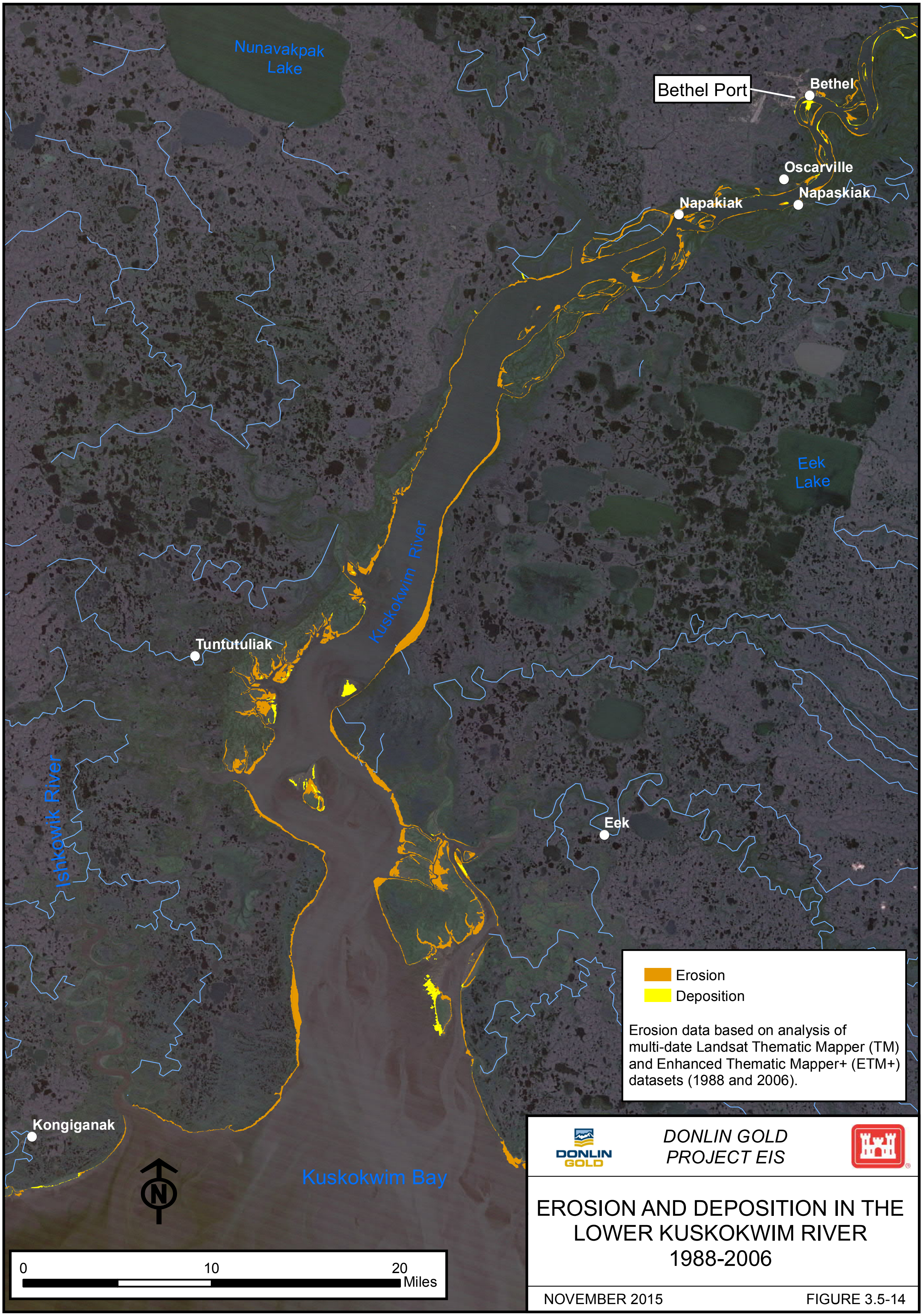
Source: Curran et al. 2003.

Bank Erosion/Scour

Melting permafrost and ice jams are two of the main mechanisms of bank erosion and channel migration on the Kuskokwim River. Bank erosion in permafrost environments is called "thermo-erosional niching," which is the process by which banks are undercut by concurrent thawing and erosion (Scott 1978). The river water thaws and erodes the frozen sediment below the water surface. As the bank becomes undercut, it eventually breaks off and the process begins again. Ice jams are common on the Kuskokwim River and frequently occur in secondary channels of the river (BGC 2007c). The presence of an ice jam in a secondary channel often causes the volume of water in the main channel to increase, resulting in increased bank erosion (BGC 2007c).

Channel migration on the Kuskokwim River was studied between the mouth of the river and Crooked Creek by comparing aerial photography taken in 1988 and 2006 (ARCADIS 2007a). The results of the study indicated that the most noteworthy change occurred near the mouth between 30 and 60 miles below Bethel (Figure 3.5-14), and that the maximum lateral migration was over 2,700 feet. Figure 3.5-15 shows the estimated bank erosion between Kwethluk and Crooked Creek between 1988 and 2006 (ARCADIS 2007a), the most substantial of which was between Akiachak and Tuluksak. Very little lateral bank erosion occurs upriver of Aniak. In another study, channel migration on the Kuskokwim River was studied at five locations between Akiachak and Aniak by comparing aerial photographs taken in 1950 and satellite imagery obtained in 2001. It was concluded that during this period, bank erosion rates were between 10 and 15 feet per year (BGC 2007c).

The Bethel Port site is located on a low-lying upland floodplain that is bounded by erosional scarps that range from 10 to 50 feet in height. The scarp height suggests numerous past flooding events and a dynamic ongoing process of aggradation and degradation of stream banks of the Kuskokwim River.

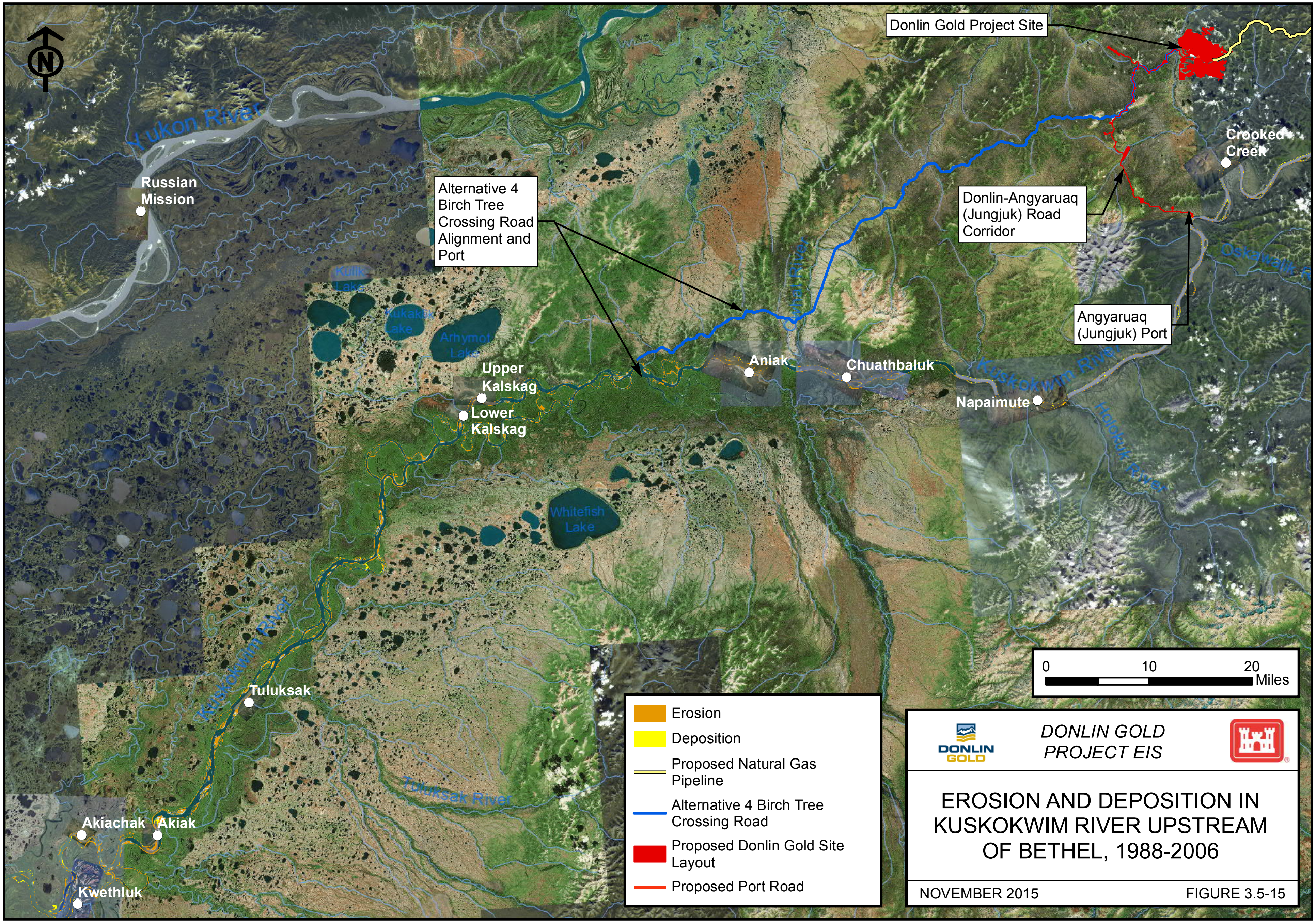


DONLIN GOLD PROJECT EIS

EROSION AND DEPOSITION IN THE LOWER KUSKOKWIM RIVER 1988-2006

NOVEMBER 2015

FIGURE 3.5-14



DONLIN GOLD PROJECT EIS

EROSION AND DEPOSITION IN KUSKOKWIM RIVER UPSTREAM OF BETHEL, 1988-2006

NOVEMBER 2015

FIGURE 3.5-15

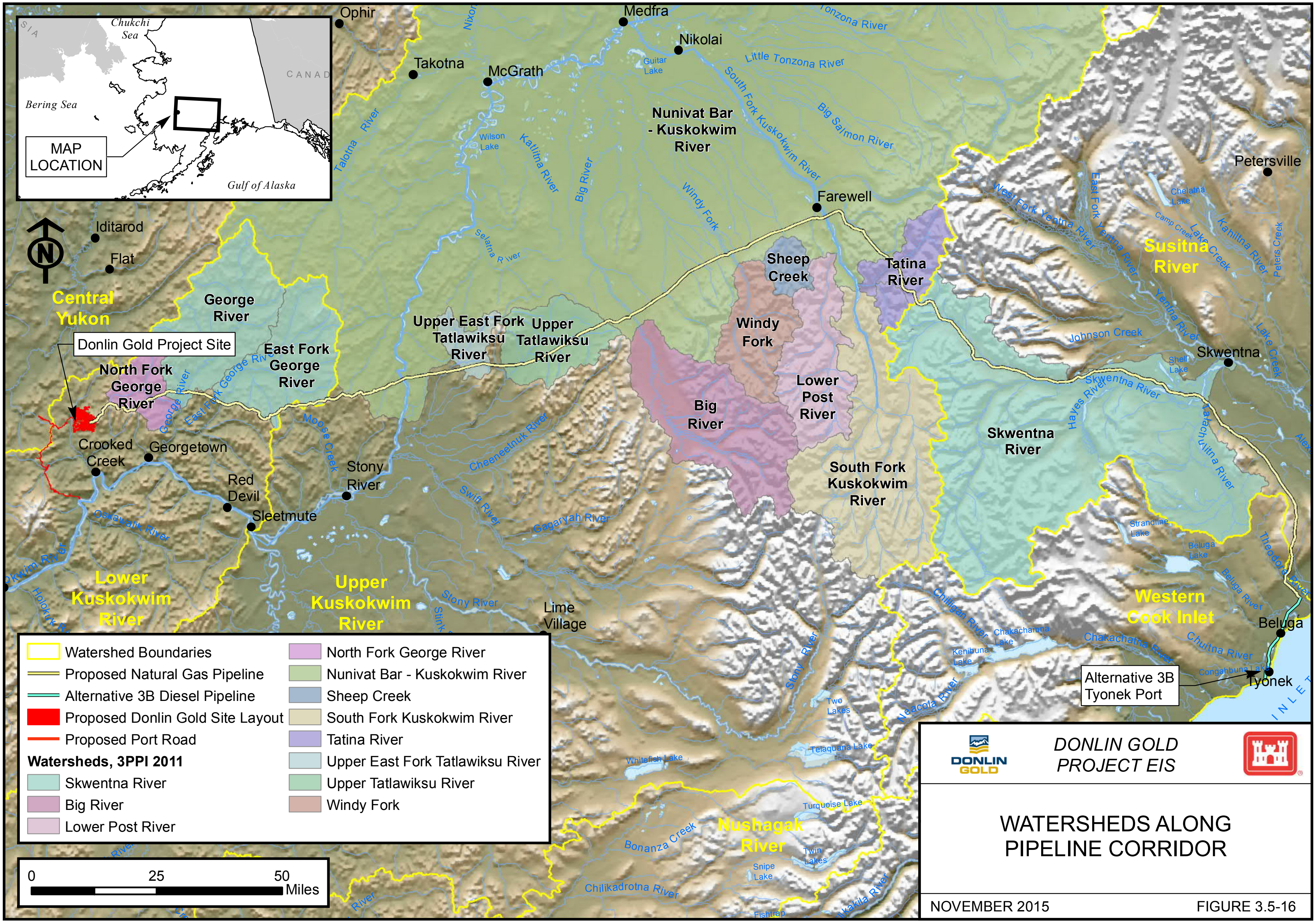
3.5.2.3 PIPELINE

Donlin Gold, LLC seeks to use natural gas to generate electricity, provide heat, and process ore for the proposed mine. The proposed gas pipeline corridor would be approximately 315 miles long, originating at the west end of the Beluga Gas Field. The pipeline would tie into the existing Beluga Natural Gas Pipeline approximately 8.5 miles west of Beluga and would run north and west to the proposed mine (Figure 3.5-16). The construction corridor for the proposed pipeline would be 150 feet wide, which includes a 100-foot wide temporary construction ROW plus the 50-foot wide permanent ROW. The pipeline route would transverse an area with little to no preexisting infrastructure.

The proposed pipeline would include one compressor station, to be located at milepost (MP) 0.4 of the pipeline, to compress the gas for transportation. The compressor station would be supplied with electric power by tying into an existing transmission line in Beluga and extending it to the facility. The above ground transmission line would be approximately 14 miles long, and would follow an existing transmission line corridor within a 30-foot wide easement to MP 0.0 of the pipeline. The transmission line would then follow the proposed pipeline corridor to the compressor station. In addition to the pipeline, temporary shoofly and pipeline access roads would be constructed within the proposed pipeline corridor. The temporary roads would be located in close proximity to the pipeline at water body crossings, and would be intended to provide vehicle access for construction of the pipeline.

3.5.2.3.1 DRAINAGE BASINS/WATERSHEDS

The proposed pipeline route would cross more than 400 streams (CH2MHILL 2011c; OtterTail 2012a). The rivers and streams that the proposed pipeline would cross are listed in Table 3, Appendix G. Stream types along the proposed pipeline route include small coastal streams, headwater streams, and braided systems fed by glaciers. The watersheds discussed in this section, shown on Figure 3.5-16, are located within one of two regions: Cook Inlet or Alaska Interior. The two regions are divided by the Alaska Range, which would be crossed by the pipeline at MP 118. Cook Inlet watersheds traversed by the proposed pipeline route between MP 0.0 and MP 118 drain either directly into Cook Inlet or into tributaries of the Susitna River. Alaska Interior watersheds traversed by the pipeline between MP 118 and MP 315 are all tributaries of the Kuskokwim River.



DONLIN GOLD PROJECT EIS

WATERSHEDS ALONG PIPELINE CORRIDOR

NOVEMBER 2015

FIGURE 3.5-16

Cook Inlet Region Watersheds

Theodore and Lewis River Watersheds

The Cook Inlet region is a broad plateau flanked to the north and west by foothills of the Alaska Range and to the south and east by Cook Inlet. Watersheds in this region contain numerous small lakes and wetlands, with discontinuous hills and low-lying areas typical of highly glaciated terrain. The start of the proposed gas pipeline and the compressor station would be located in the Theodore River watershed (Figure 3.5-17). The pipeline would cross the mainstem of the Theodore River at MP 5.5, and then enter the Lewis River watershed at MP 6. The pipeline would not cross the mainstem of Lewis River; however, it would cross multiple small tributary streams along the west side of the Lewis River, exiting the watershed at MP 16.7. The Theodore and Lewis rivers drain directly into Cook Inlet. The drainage area of the Theodore River above the pipeline crossing is approximately 103 square miles. The Theodore River's headwaters are west of Little Mount Susitna, and include the western slopes of Little Mount Susitna and a low-lying area containing numerous small lakes and wetlands. The Lewis River tributaries that would be crossed by the proposed pipeline have drainage areas ranging in size from less than 0.5 square miles to just over 2 square miles. The Lewis River headwaters include the east slope of Little Mount Susitna, the west slope of Mount Susitna, and a low-lying area between the two mountains containing small lakes and wetlands.

Alexander Creek Watershed

The proposed pipeline would enter the Alexander Creek watershed at MP 16.7, traversing the watershed along the west side of the creek. Alexander Creek is a tributary of the Susitna River, which flows into Cook Inlet to the east of Lewis River. The pipeline would not cross the main channel of Alexander Creek; however, it would cross numerous tributary streams with drainage areas ranging from less the 0.5 square miles to just over 17 square miles. Some of the named Alexander Creek tributaries that would be crossed by the pipeline include Wolverine Creek, Upper Sucker Creek, Bear Creek, Clear Creek and Deep Creek. The majority of the Alexander Creek tributary streams that would be crossed by the pipeline originate on the slopes of Mount Susitna, Little Mount Susitna, and Beluga Mountain.

Skwentna River Watershed

The proposed pipeline would enter the Skwentna River watershed at MP 43.5, traversing the western portion of Eightmile Creek, a tributary drainage of the lower Skwentna River (Figure 3.5-16). The Skwentna River is a tributary to the Yentna River, which flows into the Susitna River north of the Alexander Creek confluence. The pipeline would cross the Skwentna River at MP 50. The drainage area at this location is approximately 2,223 square miles, the second-largest watershed traversed by the proposed pipeline. After the Skwentna River crossing, the pipeline would head west along the north side of the river, initially crossing several small tributaries that originate from small lakes and wetlands, typical of Lower Cook Inlet drainages. The topographic relief of the Skwentna River watershed increases west of MP 50, with tributaries extending into the steep glaciated mountains of the Alaska Range.

At MP 86, the pipeline would cross the lower Happy River channel, a tributary of the upper Skwentna River with a drainage area of approximately 337 square miles at the pipeline crossing. The pipeline would traverse northwest along the south side of Happy River and cross Canyon, Squaw and Indian creeks. Squaw Creek and Indian Creek are glaciated streams with drainage areas at the proposed pipeline crossing of approximately 13 and 18 square miles, respectively. The pipeline would cross the upper Happy River channel near MP 108 and traverse north along the west side of the Three-mile Creek tributary, exiting the upper Skwentna River watershed near MP 116 at an elevation of roughly 4,200 feet.

Kuskokwim River Watersheds

Alaska Range

The proposed pipeline would cross into the headwaters of the South Fork Kuskokwim River, entering a small tributary to the Tatina River, called So Long Creek, at MP 118 (Figure 3.5-16). The pipeline would parallel So Long Creek along its west side, crossing several small tributaries and eventually crossing the mainstem channel near MP 123. The pipeline would continue northwest along the east side of So Long Creek, crossing the Tatina River near MP 127. The Tatina is a braided river, fed from glaciers in the Alaska Range, with a drainage area of 106 square miles at the proposed pipeline crossing.

After the Tatina River crossing, the pipeline would cross into the Jones River watershed, a tributary of the South Fork Kuskokwim River. The Jones is a braided river with headwaters in the steep mountains of the Alaska Range, flowing north out of the mountains onto the low-lying upland plateau of Interior Alaska that extends north from the base of the Alaska Range. The pipeline would follow the west side of the Jones River, crossing several small tributaries and eventually crossing the main channel two times; once near MP 136.5 and once near MP 137.5. The pipeline would exit the Jones River watershed near MP 143.5, turn west, and traverse the northern base of the Alaska Range.

The proposed pipeline would cross the South Fork Kuskokwim River near MP 146-147, the third-largest river along the proposed pipeline route. The South Fork flows north and is a large braided system, fed from glaciers in the Alaska Range, with a drainage area of 1,696 square miles at the proposed pipeline crossing. The pipeline would cross the river at an elevation of 1,300 feet; the mean basin elevation is over 4,000 feet above the pipeline crossing. After the South Fork crossing, the pipeline would cross multiple smaller streams with drainage areas ranging from less than 0.5 square miles to 87.7 square miles. These drainages are not glacially fed. They originate in the Alaska Range foothills and mountains and flow north to their respective confluences on the broad interior plateau. Some of these tributaries are braided, but most are single-channel streams.

North Front Alaska Range

Near MP 168, the proposed pipeline would cross the Windy Fork Kuskokwim River, a braided system with glaciers in upper headwater tributaries of the Alaska Range. The Windy Fork flows north and has a drainage area of approximately 290 square miles at the proposed pipeline crossing. The pipeline would cross the Windy Fork at an elevation of 1,400 feet; the mean basin elevation is close to 4,000 feet above the pipeline crossing. After the Windy Fork Crossing, the pipeline would continue west, crossing several tributaries of the Middle Fork Kuskokwim River. These tributaries originate in the Alaska Range, flow north, are not glacially fed, and have drainage areas ranging from less than 0.5 square miles to just over 18 square miles. Some of these tributaries are braided, but most are single-channel streams. The major river the pipeline would cross in this area is the Middle Fork near MP 183, a braided, glacially fed river originating in the Alaska Range. The Middle Fork flows north and has a drainage area of approximately 84 square miles.

The pipeline would traverse into the Big River watershed near MP 191-192, crossing several tributaries of Big River along the route. These tributaries have drainage areas ranging from less than 0.5 square miles to 3.28 square miles, and are single-channel streams flowing north out of the lower foothills of the Alaska Range. The glaciated permafrost terrain in the Big River area supports numerous lakes and ponds. Big River flows north to its confluence with the main fork of the Kuskokwim River. It is a glacially fed, braided river originating in the Alaska Range, with a drainage area of approximately 660 square miles at the proposed pipeline crossing. The pipeline would cross Big River at an elevation of 1,000 feet, and the mean basin elevation is close to 3,300 feet above the pipeline crossing.

After the Big River, watersheds traversed by the proposed pipeline route transition from the Alaska Range to the Nushagak-Big River Hills physiographic province (Section 3.1, Geology). The proposed pipeline would cross into the upper Tatlawiksuk River watershed near MP 204. The Tatlawiksuk River is the last major tributary of the Kuskokwim River that would be traversed by the pipeline east of the Kuskokwim River crossing. The proposed pipeline route would cross more than 30 tributaries of the Tatlawiksuk River, with drainage areas ranging from less than 0.5 square miles to just over 100 square miles. The topographic relief of the watershed is moderate, made up of scattered hills mixed with low-lying areas containing small lakes and wetlands. The pipeline would cross the main channel of the Tatlawiksuk River near MP 217 at an elevation of approximately 500 feet. The river flows southwest to its confluence with the Kuskokwim River, and the drainage area at the pipeline crossing is just over 257 square miles. The mean basin elevation is close to 1,000 feet. The pipeline would cross the upper West Fork Tatlawiksuk River near MP 232, with a drainage area at the crossing of just over 100 square miles.

Kuskokwim Mountains

Near MP 240, the proposed pipeline would cross the Kuskokwim River, the largest river that would be crossed along the proposed pipeline route (Figure 3.5-16). The drainage area at the pipeline crossing is 15,165 square miles. Roughly 30 percent of the drainage area is within the Alaska Range, and the remaining 70 percent is within the Alaska Interior. The proposed pipeline would cross the river at an elevation of 250 feet, and the average elevation of the watershed above the crossing is over 1,500 feet. The channel is divided by a mid-channel island at the proposed crossing, typical of channel conditions on the Kuskokwim River.

The proposed pipeline route continues west, traversing the Kuskokwim Mountains and crossing several small tributaries of the Kuskokwim River, including the upper tributaries of Nunsatuk River and Moose Creek. These tributaries have drainage areas ranging from less than 0.5 square miles to just over 30 square miles. Near MP 270, the pipeline would cross into the George River watershed, the last watershed that would be traversed prior to reaching the proposed Donlin Gold mine site (Figure 3.5-16). The smaller tributaries that would be crossed by the pipeline have watershed areas between less than 0.5 square miles and 7.0 square miles. The larger tributaries that would be crossed include the East and North forks of George River. The East Fork pipeline crossing would be near MP 283 at an elevation of 250 feet. The drainage area here is approximately 407 square miles and the average elevation of the East Fork basin above the crossing is close to 850 feet. The pipeline would cross the main channel of George

River near MP 291 at an elevation of 250 feet. The drainage area is approximately 496 square miles and the average elevation of the George River watershed above the crossing is close to 940 feet. The last major stream crossing would be the North Fork George River, crossed near MP 298 at an elevation of 360 feet. The drainage area is approximately 108 square miles and the average elevation of the North Fork basin above the proposed crossing is close to 1,000 feet.

Diesel Pipeline – Alternative 3B

Under Alternative 3B, described in Section 2.3.4 (Chapter 2, Alternatives) the diesel pipeline would start at the Tyonek Port, located approximately 18 miles southwest of MP 0 of the natural gas pipeline route. From MP 0, the diesel pipeline would follow the same corridor as the natural gas pipeline. Along the 19-mile section between Tyonek and MP 0, the diesel pipeline would traverse six Cook Inlet watersheds ranging from large (Beluga River watershed) to small tributaries along the Cook Inlet coast (Figure 3.5-17).

Unnamed Tributaries #1, #2, and #3 Frontal Cook Inlet Watersheds

The diesel pipeline would traverse three coastal areas between the Tyonek Port and the Beluga River watershed (Figure 3.5-17). These coastal features contain numerous lakes and wetlands with small, interconnecting channels. These are nearly level areas that are typically poorly drained and may or may not be influenced by tidal fluctuations. The approximate watershed areas of Unnamed Tributary #1, #2, and #3 are 18, 4.5, and 4.7 square miles, respectively.

Chuitna River

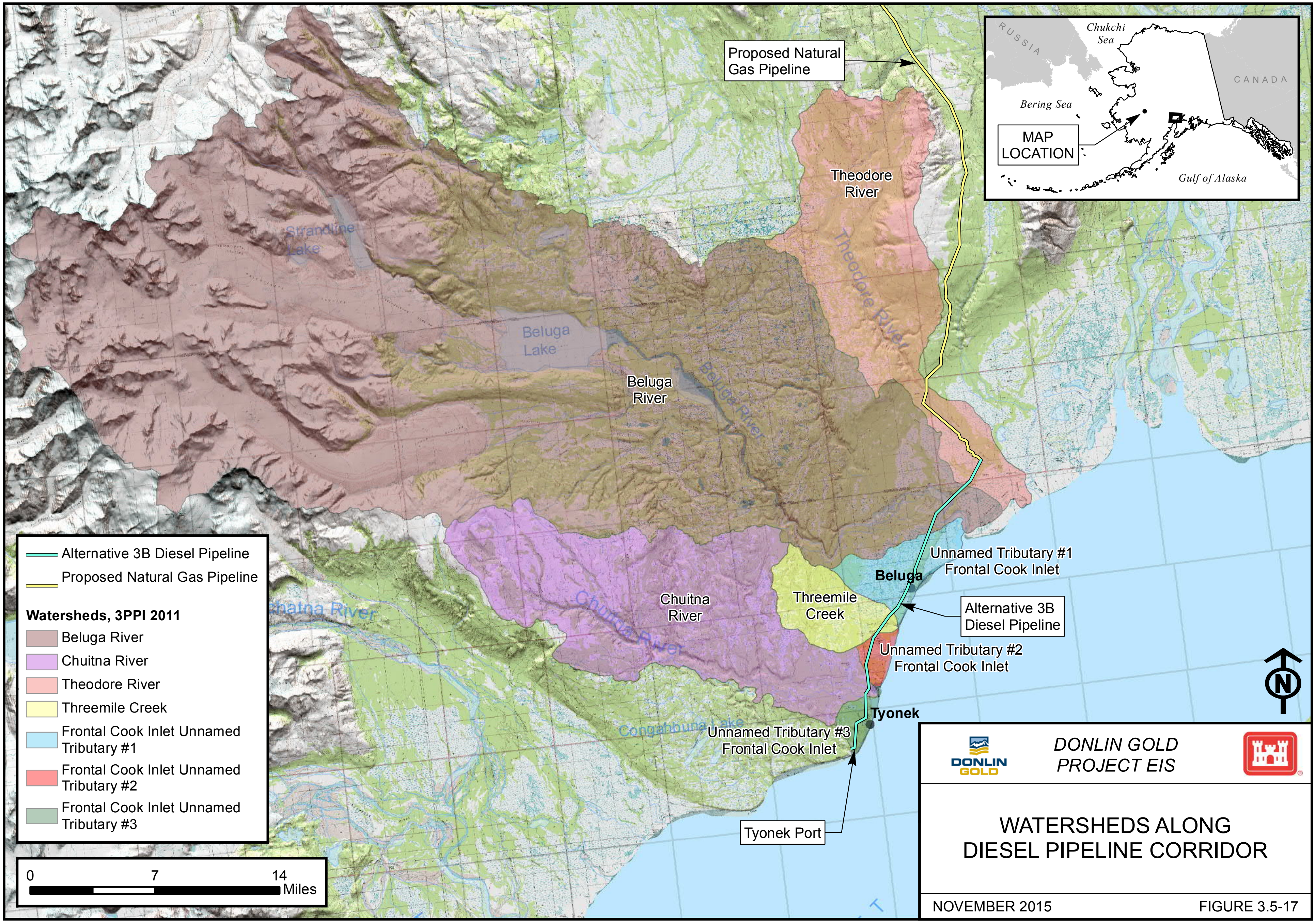
The Chuitna River watershed is bound by Cook Inlet to the south, Mount Spurr and the Alaska Range to the north, the Beluga River watershed to the east, and the Chakachatna River watershed to the west (Figure 3.5-17). The Chuitna watershed covers approximately 150 square miles, contains no glaciers, and is dominated by wetlands and low rolling hills. The Alternative 3B diesel pipeline route would cross the lower portion of the Chuitna River, near the mouth.

Threemile Creek

Threemile Creek is a small coastal watershed located between the Chuitna and Beluga River watersheds (Figure 3.5-17). Threemile Creek covers approximately 24 square miles, and is dominated by wetlands, small lakes and low rolling hills. The Alternative 3B diesel pipeline route would cross the lower portion of Threemile Creek, near the mouth.

Beluga River

The Beluga River watershed extends southeast from the Tordrillo Mountains of the Alaska Range down to Cook Inlet (Figure 3.5-17). The Beluga River covers approximately 887 square miles. The Capps and Triumvirate Glaciers are the main glaciers that exist in the upper (western) portion of the watershed. Meltwater from both glaciers flow into Beluga Lake, located in the central portion of the watershed. The Beluga River flows out of Beluga Lake. Strandline Lake is a glacial lake located north and west from Beluga Lake, formed along the northeastern edge of the Triumvirate Glacier. The Strandline Lake glacial dam failed in 1979, causing a glacial outburst flood in the Beluga River that washed out a bridge in the lower portion of the watershed (USDA 1982). This same event caused the water level in Beluga Lake to rise approximately 32 feet in a matter of hours (USDA 1982). The central and eastern portions of the watershed are dominated by wetlands, small lakes and low rolling hills. The Alternative 3B diesel pipeline route would cross the lower portion of the Beluga River, near the mouth.


Proposed Natural Gas Pipeline
Chukchi Sea
RUSSIA
CANADA
Bering Sea
MAP LOCATION
Gulf of Alaska
Theodore River
Strandline Lake
Beluga Lake
Beluga River
Theodore River
Beluga River
Chuitna River
Chuitna River
Threemile Creek
Beluga
Unnamed Tributary #1 Frontal Cook Inlet
Alternative 3B Diesel Pipeline
Unnamed Tributary #2 Frontal Cook Inlet
Tyonek
Unnamed Tributary #3 Frontal Cook Inlet
Tyonek Port
Alternative 3B Diesel Pipeline
Proposed Natural Gas Pipeline
Watersheds, 3PPI 2011
Beluga River
Chuitna River
Theodore River
Threemile Creek
Frontal Cook Inlet Unnamed Tributary #1
Frontal Cook Inlet Unnamed Tributary #2
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0
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DONLIN GOLD
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WATERSHEDS ALONG DIESEL PIPELINE CORRIDOR
NOVEMBER 2015
FIGURE 3.5-17

Winter Access Routes

To facilitate construction of the pipeline, Donlin Gold proposes to develop an approximately 46 to 50 mile, 30-foot wide winter access corridor to transport equipment and supplies for a period of approximately 3 years from the Parks Highway via Petersville Road or at Willow via the Willow Creek Parkway (Figure 2.3-23 in Chapter 2, Alternatives). The majority of the two route options have previously been utilized as commercial / industrial winter trails to support oil and gas exploration, mineral exploration and development, as well as materials and fuel transport for the numerous lodges and commercial activities in the Yentna and Skwentna River drainages (SRK 2013b).

Oilwell Road Route

The northern route alternative that extends from the Petersville Highway is identified as the "Oilwell Road Route", and would be approximately 46 miles long (Figure 2.3-23 in Chapter 2, Alternatives). From near Amber Lake the winter road would begin and follow the existing Oilwell Road ROW generally south and west across Kroto Creek to the currently utilized winter road crossing of the Kahiltna River. From the Kahiltna, the route would follow existing trials and old seismic lines to the Yentna River, crossing about 1 mile downriver of the mouth of Lake Creek. After the Yentna River, the route would continue southwesterly for several miles, crossing Eightmile Creek approximately 2 miles north of Eightmile Lake. From this point the route would primarily traverse open marshy areas and bogs until it arrives at the Skwentna River approximately 2.5 miles downriver of the mouth of Shell Creek (SRK 2013b).

Willow Landing Route

The southern route alternative would be accessed from the Parks Highway at Willow via Willow Creek Parkway, and would be approximately 50 miles long (Figure 2.3-23 in Chapter 2, Alternatives). The winter trail route begins on the east bank of the Susitna River, just downriver of Willow Creek. For the first 4.5 miles, the route crosses numerous channels and islands of the Susitna River floodplain. After traversing out of the Susitna River floodplain, the trail crosses mostly open marsh areas, crossing the Deshka River roughly 10 miles upriver of its confluence with the Susitna River. From the Deshka River, the route would continue westward for approximately 14 miles, crossing open marshy areas and low ridges, crossing the Yentna River just below the mouth of Moose Creek. After crossing the Yentna River, the route trends west, crossing the Kutna Creek, then northwesterly over open marsh lands to the Skwentna River Crossing (SRK 2013b).

3.5.2.3.2 STREAM FLOW

Existing stream flow data for the streams that would be crossed is limited due to the remote region traversed by the proposed pipeline. The only USGS gauging stations that exist along the proposed pipeline corridor are on the Skwentna and Kuskokwim rivers. The Skwentna River gauging station discharge data are considered to be representative of discharge at the proposed crossing, as the gauging station monitors roughly the same drainage area as that above the proposed crossing. The USGS gauging stations on the Kuskokwim River are located at Crooked Creek and McGrath. The drainage area above the Crooked Creek and McGrath stations are 31,100 and 11,700 square miles, respectively, while the drainage area above the proposed pipeline crossing is 15,165 square miles. Table 3.5-23 provides a summary of peak discharge record at each location.

Table 3.5-23: USGS Peak Discharge Summary for Skwentna and Kuskokwim Rivers

Watershed and USGS Site ID	Period of Record Evaluated	Minimum Annual Peak Discharge of Record (Date) (cfs)	Maximum Annual Peak Discharge of Record (Date) (cfs)	Average Peak Discharge (cfs)
Skwentna River 15294300	1960 - 1986	20,800 (09/01/1974)	69,000 (10/11/1986)	35,670
Kuskokwim River near McGrath 15303600	1963 - 1973	35,200 (05/14/1966)	70,000 (06/06/1964)	53,373
Kuskokwim River near Crooked Creek 15304000	1952 - 2012	70,000 (05/09/1997)	392,000 (06/05/1964)	168,968

Source: USGS 2013b.

Given the lack of stream flow data on the remaining streams crossed by the proposed pipeline, it was determined that the best method for estimating peak flows was through the use of USGS regional regression equations (CH2MHILL 2011a; Curran et al. 2003). A complete list of streams crossed by the proposed pipeline, including drainage area and peak-discharge estimates for select recurrence intervals, is included in Table 3, Appendix G.

Diesel Pipeline – Alternative 3B

Chuitna River

Of the streams crossed by the diesel pipeline alternative between Tyonek and MP-0 of the natural gas pipeline, the stream with discharge data is the Chuitna River. Discharge data from the USGS gauging station (station 15294450) were recorded between October 1975 and September 1986. The gauging station was located upstream from the mouth, and downstream from the confluence with the Lone Creek tributary. The drainage area above the gauging station was 131 square miles. For the period of record, average monthly discharge ranged from 84 cfs in February to 980 cfs in June. Peak discharges recorded for the period of record typically occurred in the late summer and fall, although smaller peak discharges do occur during spring breakup. On September 15, 1982, a peak discharge of 4,800 cfs was recorded at the gauging station. The highest peak discharge occurred on October 10, 1987 and is listed as being 10,000 cfs; however, this is an estimated discharge as the actual discharge is considered to be higher than the indicated value.

3.5.2.3.3 MARINE WATER

Tyonek/North Foreland

For the diesel pipeline alternative, diesel fuel would be transported up the Cook Inlet by fuel tankers. The existing Tyonek dock extends approximately 1,500 feet from the North Foreland shore. In order to accommodate draft requirements for fuel tankers supplying diesel fuel to the pipeline, the dock would be extended another 1,500 feet (Figure 2.3-39 in Chapter 2, Alternatives). The water depth at this location is sufficient such that it would not be necessary to dredge at the dock or in shipping channels, either initially or for maintenance. Navigation charts indicate that large boulders protrude above the sea floor in the vicinity of the dock extension that would likely be a navigation hazard. A bathymetric survey would be completed prior to design and construction to identify the exact location of these boulders.

Glacial fed rivers, including the Susitna and Knik Rivers, flow into the upper Cook Inlet, depositing large amounts of silt in the inlet. This silt remains suspended for long periods of time before it settles to create both mudflats and shoals that are highly changeable. Most of the change is due to the fact that the inlet has the second largest tidal fluctuations in the world (maximum tidal fluctuations as high as 30 feet can occur). The range of these fluctuations frequently exceeds 19 feet and tidal velocities can reach 8 knots (Mildon et al. 2009).

Ice is found in the Upper Cook Inlet for much of the winter. The northern half is ice-covered by December. Typically during the winter months, 4 inches of “pancake ice” forms over the surface of the Upper Cook Inlet. During colder winters, heavier flows of ice reaching a thickness of 6.5 feet may form. Any ice that does form is consistently broken and transported by the strong tidal currents throughout the Inlet (Mildon et al. 2009).

3.5.2.3.4 SURFACE WATER USE

With the exception of the Beluga-Tyonek area, most of the proposed pipeline route is located in remote areas with very little documented public water use. It is possible that surface water is used for domestic supply at scattered private parcels and mining claims in the Skwentna River valley, and Native allotments near the mainstem Kuskokwim River and George River crossings.

Community and industry water supplies in the Beluga-Tyonek area are mostly from groundwater wells (Section 3.6, Ground Water Hydrology). An instream flow reservation exists on the Chuitna River about 8 miles upstream of the diesel pipeline alternative near Tyonek. Surface water rights are currently held for Viapan Lake, located adjacent to the proposed pipeline about half-way between Tyonek and Beluga, and by ConocoPhillips at a location near the Beluga Power Plant (ADNR 2013e).

A number of existing TWUAs are held by oil and gas industry and mining exploration companies in sections crossed by the proposed pipeline and diesel alternative routes. These include ConocoPhillips, Hilcorp, and Aurora Gas in the Tyonek-Beluga area; and Geoinformatics and Kiska Metals in the upper Skwentna River drainage.

3.5.2.3.5 PROPOSED SURFACE WATER EXTRACTION SITES

Approximately 130 water bodies along the pipeline are proposed for use as surface water extraction sites during pipeline construction (Table 4, Appendix G) (SRK 2013b). Most of these are streams and rivers crossed along the proposed pipeline route. Water in about three-fourths of the streams would be withdrawn in winter only, and the rest in summer or both seasons. About 15 of the surface water extraction sites are lakes and ponds that would be mostly accessed in winter only. These include scattered ponds in the Mount Susitna and Skwentna Valley areas, and several lakes and ponds located in the glaciated terrain on either side of Big River (Section 3.5.2.3.2).

3.5.2.3.6 BANK EROSION/SCOUR

Stream bank erosion is caused by a change in stream morphology from an increase in stream flow, usually during flood events. Bank erosion data have been collected by OtterTail (2013) at about one-third of the stream crossings along the proposed pipeline route. Of these, about 20 exhibit active erosion on one or both banks; about 70 show signs of slight erosion; and about 100 show no existing erosion. Soils in permafrost areas that may be particularly vulnerable to stream bank erosion are described in Section 3.2, Soils, and Table 3.2-7.

Active river erosion has also been mapped along some of the larger streams and rivers as part of geotechnical investigations conducted along parts of the proposed pipeline corridor. For example, terrain mapping conducted by BGC (2013c) indicates ongoing river erosion occurring along the Jones and South Fork Kuskokwim rivers as they exit the Alaska Range flowing north (Figure 3.3-4 in Section 3.3, Geohazards and Seismic Conditions). Similar conditions are expected to exist at other large braided streams and rivers crossed by the proposed pipeline route. Pipeline segments crossing historic floodplain landforms are documented in Appendix G, Table 3.

3.5.2.4 CLIMATE CHANGE

Climate change is affecting resources in the EIS Analysis area and trends associated with climate change are projected to continue into the future. Section 3.26.3 discusses climate change trends and impacts to key resources in the physical environment including atmosphere, water resources, and permafrost. Current and future effects to surface hydrology are tied to changes in water resources (discussed in Section 3.26.3.2).

3.5.3 ENVIRONMENTAL CONSEQUENCES

This section describes the temporary and permanent activities associated with construction, and operations and maintenance of the Donlin Gold Project, and the direct and indirect potential impacts of the proposed project on surface water. Table 3.5-24 presents the impact criteria used for analyzing impacts to surface water resources.

Table 3.5-24: Impact Criteria for Surface Water Resources

Type of Effect	Impact Component	Effects Summary		
Changes to Water Quantity	Magnitude or Intensity	**Negligible to Low**: Surface water flow systems are maintained. Changes in water quantity are likely to be within the limits of historic seasonal variation.	**Medium**: Changes in the surface water flow system are likely to result in changes to flow quantity that exceed historic seasonal variation, and/or the historic location of the flow, but nearby uses and environments are likely to be maintained, and the surface water flow system design is likely to be adequate for the expected range of conditions.	**High**: Substantial flow diversions and changes in flow systems are likely to affect nearby uses or environments, or the surface water flow system design is not likely to adequately protect nearby uses or environments for the expected range of conditions.
	Duration	**Temporary**: Surface water quantity would be changed during a particular activity (e.g., construction) but is expected to return to pre-project levels at the completion of the activity.	**Long-term**: Surface water quantity would be changed throughout most of the life of the project, but would return to pre-project levels at some time after completion of the project.	**Permanent**: Surface water quantity is not anticipated to return to pre-project conditions after completion of the project.
	Geographic Extent	**Local:** Impacts are limited to discrete portions of the Project Area. Hydraulically connected waters beyond the Project Area are not affected.	**Regional:** Impacts affect hydraulically connected waters beyond the Project Area.	**Extended:** Impacts affect hydraulically connected waters in region beyond those of the EIS Analysis Area.
	Context	**Common:** Impacts affect usual or ordinary resources; not depleted or protected by legislation.	**Important:** Impacts affect depleted or shared resources within the locality or region, or resource hazards governed by regulation.	**Unique:** Impacts affect unique resources or resources protected by legislation.

Notes:
Unless stated otherwise, potential changes to surface water quantity for each component of the mine project, including the mine site, transportation facilities, and natural gas pipeline, the following statement applies to context: because surface water is an abundant resource, but one that is governed by regulation and there are other users of waters affected by the project, the context of impacts is considered common to important.

3.5.3.1 ALTERNATIVE 1 – NO ACTION

Under the No Action Alternative, the proposed Donlin Gold Project would not be constructed, and there would be no surface water impacts.

3.5.3.2 ALTERNATIVE 2 – DONLIN GOLD'S PROPOSED ACTION

3.5.3.2.1 MINE SITE

Under Alternative 2, surface water quantity and distribution in Snow Gulch, Lewis Gulch, American Creek, Omega Creek, Unnamed Creek SE1, and Anaconda Creek watersheds would be disrupted during all or part of the construction, operations and reclamation phases of the Donlin Gold Project (Figure 3.5-18). Changes to surface water drainage within affected watersheds would result from construction of access roads and related drainage structures; camp facilities and airstrip; mine tailings, waste rock storage, and water storage impoundments; and excavation of the mine pit and associated dewatering activities. The following sections describe the potential impacts to surface water during the different phases of the mine under Alternative 2.

<u>Mine Water Balance</u>

The water management plan includes strategies for surface water management. Water management strategies were evaluated using both deterministic and stochastic (probabilistic) water balance models calibrated to mine area precipitation and stream flow data (SRK 2012b). Water balance models were developed for each phase of the project to estimate fresh water requirements, pond storage volumes, water treatment requirements, and surface water flow rates (BGC 2011f). A description of water balance input parameters and calibration is presented in Section 3.5.2.1.3.

<u>Construction</u>

Water Balance/Management

A water management plan was developed to account for surface water distribution within the mine site, including developed and undeveloped areas within affected watersheds (Figure 3.5-18). The primary water management objectives (SRK 2012b) during the construction phase include the following:

- Minimize the need to treat and discharge contact water (other than pit dewatering groundwater);
- Treat and discharge pit dewatering groundwater as necessary to minimize the volume of contact water in the American Creek Lower CWD;
- Develop an adequate supply (quantity and quality) of water for process plant commissioning; and
- Avoid water storage in the TSF prior to process plant start-up.

Additional water management activities for site access roads, construction camp site, construction water treatment plant site, and trenching for water diversion pipelines and culverts will be focused on stormwater and sediment control using BMPs. These include (but are not limited to) silt fences, sediment detention basins, and brush berms. These aspects of construction water management will be developed further in a SWPPP (SRK 2012b). The SWPPP is required as part of the mine permitting process for stormwater discharges.

Additional details regarding erosion control at the mine site are presented in Sections 3.2.3.2.1 and 3.2.3.2.4 (Section 3.2, Soils).

Stream Flow and Runoff Alterations

American Creek

Under pre-mining conditions, American Creek contributes about 3 to 24 cfs of flow to Crooked Creek, which has a discharge of about 55 to 334 cfs below the mine site (summer monthly averages, Section 3.5.2.1.2). Mine site development during construction that would alter surface water distribution within the American Creek watershed and ultimately remove nearly all flow contribution to Crooked Creek includes the Lower CWD, the American FWDD, the WRF (bare ground), mine footprint pre-stripping, and mine pit dewatering groundwater treatment and discharge to Crooked Creek at Outfall 001 (Figure 3.5-18). The average annual flow for mine water supply and distribution components used in the construction phase water balance in American Creek are presented on Figure 3.5-19.

Design criteria selected for dams constructed in the American Creek watershed meet or exceed ADNR Dam Safety Guidelines for hydrology, hydraulic, and seepage requirements (ADNR 2005). Design storage requirements of all dams constructed within the mine site are presented in Table 3.5-25, and additional hazard classifications are discussed in Section 3.3, Geohazards and Seismic Conditions. Where applicable, additional construction procedures were included in the design of the dams from the following federal agencies (BGC 2011c):

- U.S. Bureau of Reclamation;
- U.S. Army Corps of Engineers (Corps);
- Federal Emergency Management Administration; and
- Canadian Dam Association.

Additionally, water withdrawal for uses associated with mine site development would be controlled by applicable permits, which would establish limits on the amount of water withdrawn from any source and provide requirements for fish protection. Water withdrawal would be permitted and would therefore meet the requirements of ADF&G and ADNR for a water withdrawal permit. The rate and volume of water withdrawn would be monitored at each source to ensure permit requirements are met.

Table 3.5-25: Storage Requirements and Dam Crests

Facility	Flood Volume Storage Requirement (acre-feet)	Spillway Design Discharge Requirement	Freeboard[1] (feet)	Final Dam Crest Elevation (feet)	Final Dam Height (feet)
American Creek Watershed[2]					
Lower CWD[3]	7,151 (maximum operating pond of 3,283 acre-feet plus 24-hour PMP)	-	3.3 (above stored flood)	673	151

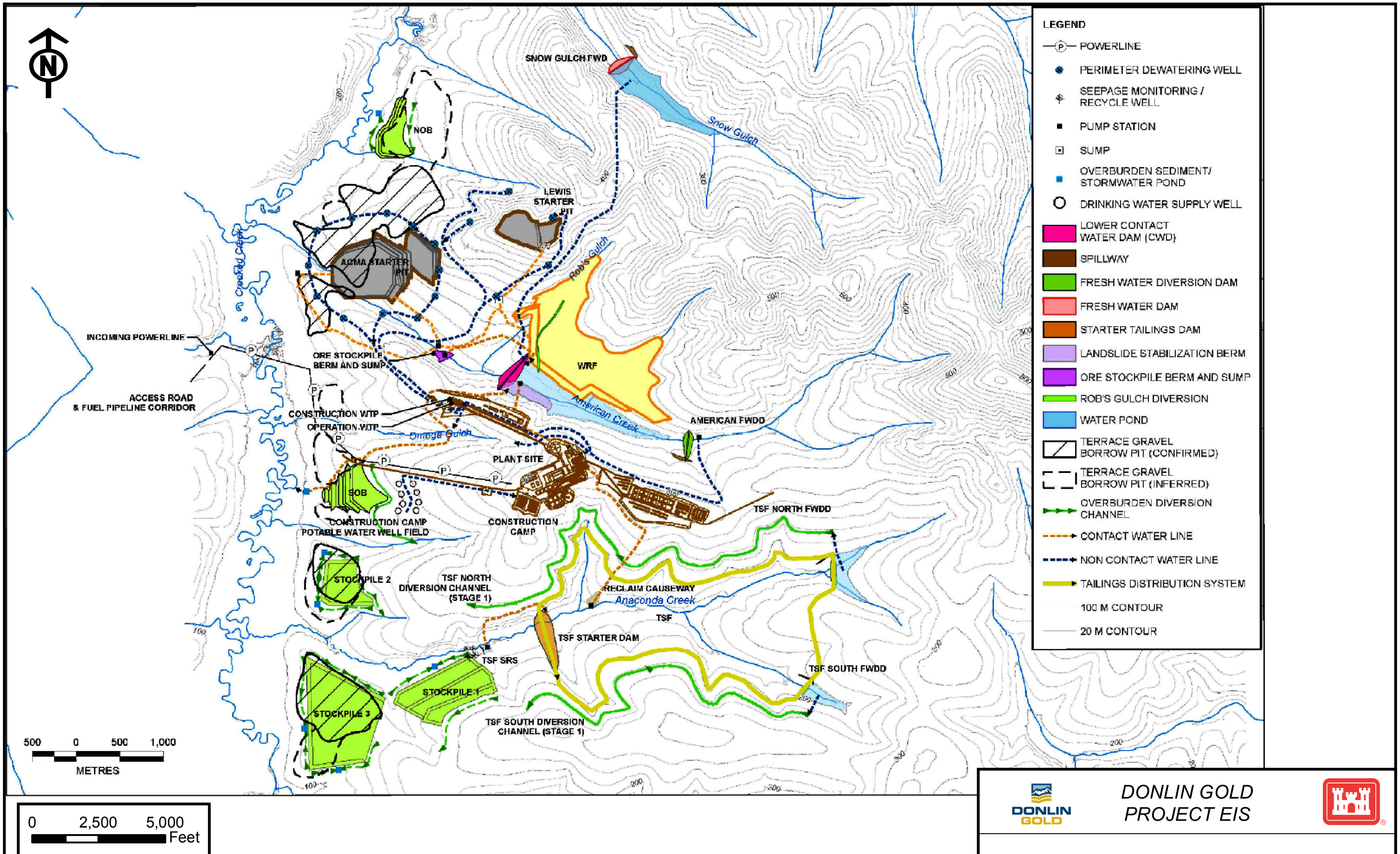
Table 3.5-25: Storage Requirements and Dam Crests

Facility	Flood Volume Storage Requirement (acre-feet)	Spillway Design Discharge Requirement	Freeboard[1] (feet)	Final Dam Crest Elevation (feet)	Final Dam Height (feet)
Upper CWD	2,342 (PMF associated with 24-hour PMP)	24-hour PMF	3.3 (above routed flood)	1,130.2	190
American FWDD	867 (100-year snowmelt)	100-year peak instantaneous flood	3.3 (above routed flood)	761	95
Snow Gulch Watershed[2]					
Snow Gulch FWD	3,243	100-year peak instantaneous flood	3.3 (above routed flood)	756	154
Anaconda Creek Watershed[4]					
TSF Starter Dam[5]	200-year snowmelt plus the PMF associated with 24-hour PMP	-	6.6 (above stored flood)	567	177
TSF Final Dam[6]	200-year snowmelt plus the (PMF associated with 24-hour PMP) 24-hour PMP	24-hour PMP (closure spillway)	6.6 (above stored flood)	833	464
TSF Seepage Recovery System[7]	16.2 (plus the 200-year, 24-hour rainfall event)	-	-	-	-
North FWDD	478 (100-year snowmelt)	100-year peak instantaneous flood	5.0 (above routed flood)	656	74
South FWDD	211 (100-year snowmelt)	100-year peak instantaneous flood	5.0 (above routed flood)	656	66

Notes:

1 Wave run-up and wind set-up heights estimated above the stored flood for each facility were less than the minimum height of 3.3 feet above the routed flood. The Lower CWD is not designed to pass water; therefore the 3.3 feet emergency freeboard height is applied above the stored flood.
2 Data source: *American Creek and Snow Gulch Contact and Fresh Water Dam Design* (BGC 2011c).
3 Storage requirements during construction are governing.
4 Data source: *Tailings Storage Facility Design* (BGC 2011a), and *Water Management Plan* (SRK 2012b)
5 In addition to the stored flood, the TSF starter dam storage design includes 12 months of tailings, operating pond, and freeboard.
6 Constructed in 5 stages, one stage every 4 years, starting the first year of operation.
7 The seepage recovery pond is designed to store three days of underdrain flow plus the 200-year, 24-hour rainfall event.

PMP = probable maximum precipitation
PMF = probable maximum flood



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Data Source: Donlin Gold 2012

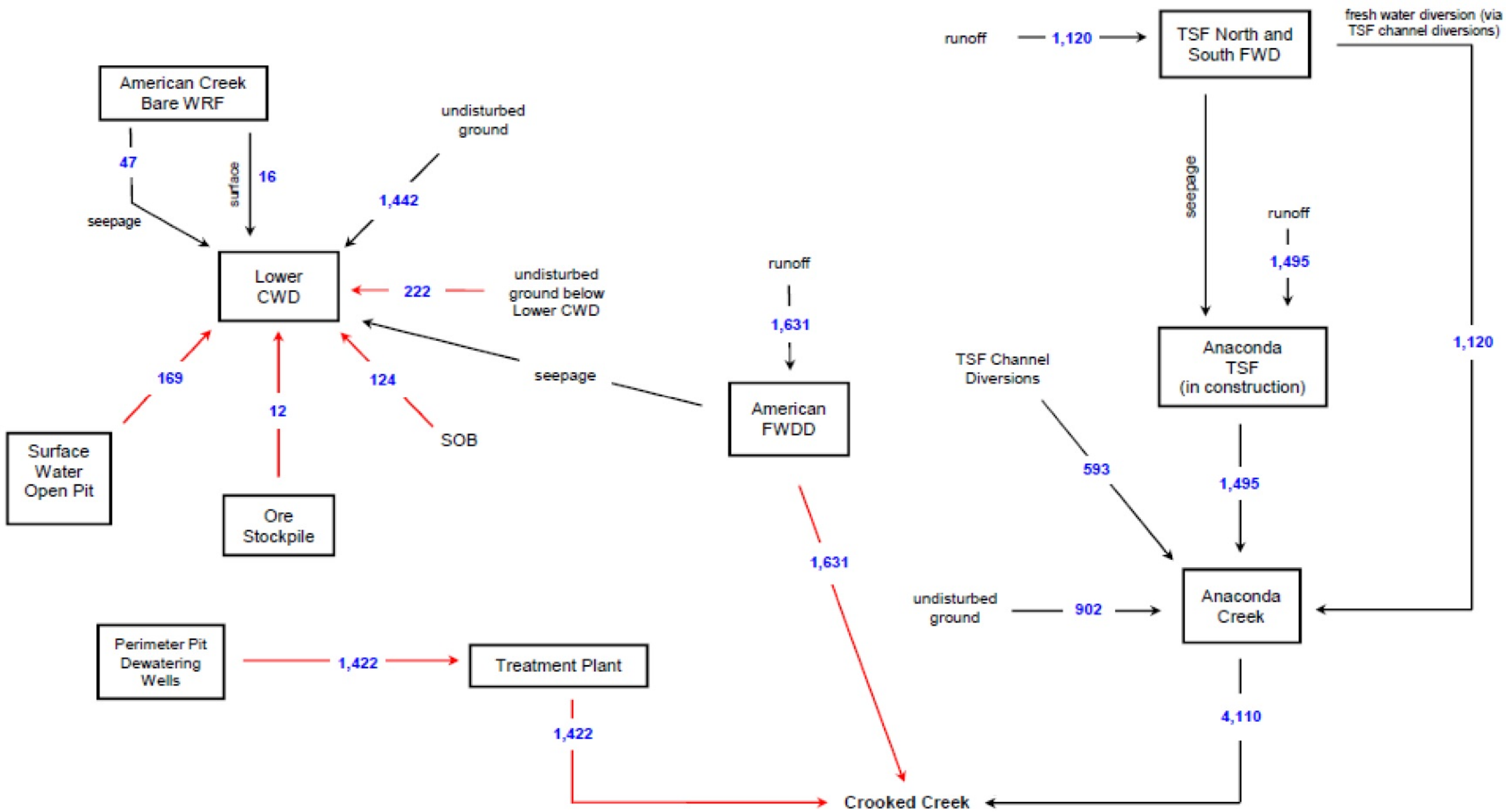
DONLIN GOLD

DONLIN GOLD PROJECT EIS

WATER MANAGEMENT PLAN DURING CONSTRUCTION

NOVEMBER 2015

FIGURE 3.5-18



NOTE: Values shown are averaged over the simulation period and represent average precipitation conditions. Rates are in USgpm. Red arrows denote pumping routes.

Data Source: Donlin Gold 2012

DONLIN GOLD PROJECT EIS

SCHEMATIC WATER BALANCE DURING CONSTRUCTION

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FIGURE 3.5-19

American Creek FWDD. The American Creek FWDD would be located upstream of the WRF, collecting runoff from 1,705 acres above the dam (Figure 3.5-18). Construction of the American FWDD would be completed about 6 months prior to the construction of the Lower CWD downstream, reducing the drainage to the Lower CWD. The water stored behind the FWDD would be used as process water during the first year of operations as needed.

Based on ADNR Dam Safety Guidelines, the American FWDD would likely have a significant or low (Class II or III) hazard potential classification (ADNR 2005; Cobb 2014). The FWDD would have a maximum storage capacity of 867 acre-feet and 3.3 feet of freeboard - a volume sufficient to store runoff from a 100-year snowmelt event (Table 3.5-25). Unless drought conditions might occur, freshwater accumulation will be kept to a minimum. Freshwater not required for storage will be pumped to Crooked Creek at Outfall 001 and discharged as non-contact water. The FWDD spillway, located on the left abutment, is designed to pass the 100-year peak instantaneous flow (BGC 2011c). Therefore, the installed pumping capacity would have a maximum flow rate of 3,963 gallons per minute (gpm). The average annual flow rate of freshwater pumped from the FWDD to Omega Gulch during the 3-year construction period is shown on Figure 3.5-19.

Lower CWD. The Lower CWD would collect runoff and seepage from the WRF and open pit footprints during the construction phase, stored for later use during operations. Construction of the Lower CWD would take place after completion of the FWDD, reducing the drainage area above the Lower CWD to 1,730 acres (SRK 2012b). Based on ADNR Dam Safety Guidelines, the Lower CWD would likely have a significant (Class II) hazard potential classification (ADNR 2005; Cobb 2014). For dams with a significant hazard rating, the inflow design flood (IDF) is defined as the probable maximum flood (PMF), including snowmelt. The PMF is based on the 24-hr probable maximum precipitation (PMP) occurring when the ground is fully saturated and thus, assumes the entire PMP runs off the catchment area without infiltration (BGC 2011c). The Lower CWD would have a total storage capacity of 7,151 acre-feet during the construction phase, with a 3.3-foot freeboard (Table 3.5-25). This storage volume includes a volume of contact water for which there is a 99 percent chance that the actual volume will be less during construction and the runoff volume associated with the 24-hour PMP (SRK 2012b). The Lower CWD would not have a spillway, and water accumulated during construction would be pumped to either the Upper CWD (to be constructed during the first year of operations, discussed below) or to the TSF in Anaconda Creek.

In addition to runoff from the WRF, the Lower CWD would receive water during the construction period from the following sources: undisturbed ground above the dam; the open pit; ore stockpile; southern overburden stockpile; and the undisturbed ground below the Lower CWD (Figure 3.5-19). The average annual flow rate from each source entering the Lower CWD during the 3-year construction period is shown on Figure 3.5-19.

WRF – Rock Drains. A description of the WRF design is presented in Section 2.3.2.1 (Chapter 2, Alternatives), and Figure 3.5-18 shows the approximate footprint of the WRF by the end of the construction phase. The WRF will be developed following the construction of the FWDD and Lower CWD, and will be constructed from the lower (downstream) end first, extending north and east up the American Creek valley as waste rock is removed from the open pits (BGC 2011b). Runoff estimates for the 100-year return period and 24-hour duration rainfall event indicate that the peak instantaneous flow out of the toe of the WRF would be approximately 265 cfs (BGC 2011b). This amount of flow warrants the construction of engineered rock drains in the

American Creek valley bottom and contributing tributaries. The average annual flow from surface runoff and seepage entering the Lower CWD from the WRF over the course of the construction period is shown on Figure 3.5-19.

Rob's Gulch. Rob's Gulch is a tributary of American Creek that has a drainage area of approximately 630 acres (SRK 2012b). Rob's Gulch enters American Creek downstream of the proposed Lower CWD (Figure 3.5-18). Rob's Gulch will be filled with waste rock during the construction of the WRF, therefore, runoff from Rob's Gulch will be diverted to the Lower CWD through a 4-foot diameter culvert that will extend beneath the initial lifts of waste rock and discharge water just upstream from Lower CWD.

Ore Stockpile Berm. The ore stockpile will be located downstream of the Lower CWD (Figure 3.5-18). A berm will be constructed along the lower end of the stockpile that will collect runoff from ore (process-affected water), and contact water from shallow seepage from the Lower CWD and seepage from the lower reaches of Rob's Gulch below the diversion (SRK 2012b). The water collected behind the berm will be pumped to the Lower CWD during the construction period (Figure 3.5-19).

Pit Dewatering Wells. Dewatering wells will be installed in and around the ACMA pit, which is located in the lower portion of American Creek near Crooked Creek (Figure 3.5-18). Pumping from the dewatering wells would begin approximately 6 months prior to pre-stripping activities. The water from the wells will be pumped to a water treatment plant and discharged into Crooked Creek (SRK 2012b). During the construction period, the average annual flow of perimeter pit groundwater that will be treated and released to Crooked Creek at Outfall 001 is shown on Figure 3.5-19.

Open Pit Runoff. It is anticipated that near the end of the second year of construction, the mine pit footprint would be approximately 99 acres (SRK 2012b). Runoff from the mine pit footprint will be considered contact water. Therefore, a berm will be constructed along the downgradient side of the pit excavation to collect runoff. This water would be pumped to the Lower CWD during the construction phase (Figure 3.5-19).

Summary – American Creek. Surface water diversion and storage, and interception of surface and groundwater by the mine pit and pit dewatering within the American Creek watershed during the construction phase, would result in a reduction in watershed yield and subsequent discharge to Crooked Creek that is likely to exceed historic seasonal variation, and represents a substantial change in the American Creek flow system. Thus, the magnitude of the direct and indirect impacts on American Creek is expected to be high. As the impact of some of these operations will extend beyond reclamation, the duration of the impact is expected to be permanent. Since water is being diverted from Crooked Creek and will have at least a small impact on Crooked Creek flows, but will likely have a negligible impact on the Kuskokwim River, the geographic extent of impacts would range from local to regional.

Anaconda Creek

Under pre-mining conditions, Anaconda Creek contributes about 5 to 13 cfs of flow to Crooked Creek, which has a discharge of about 80 to 160 cfs below the mine site (summer monthly averages, Section 3.5.2.1.2). Various activities during the construction period would partially limit flow in Anaconda Creek from reaching Crooked Creek. The TSF starter dam and two FWDDs would be constructed in the Anaconda Creek watershed, south of the WRF (Figure 3.5-18). Construction of the TSF is estimated to take 2.5 years during the construction phase and would be completed approximately 9 months prior to the operations phase beginning (SRK 2012b). The tailings impoundment will be lined with a 60-mil textured LLDPE liner to minimize tailings contact-water seepage (BGC 2011a). To effectively convey base flow beneath the TSF liner, engineered rock drains would be constructed along Anaconda Creek and contributing tributaries as the TSF expands up the valley. Additional detail of the TSF design is presented in Sections 2.3.2 (Chapter 2, Alternatives) and 3.3.3.2 (Geohazards and Seismic Conditions).

TSF Dam. The TSF starter dam foundation preparation would occur first, and would be initially designed to store 1 year of tailings plus flood storage and freeboard (BGC 2011a). Construction of the final TSF dam would resume during the operation period. Based on ADNR Dam Safety Guidelines, the TSF would likely have a high (Class I) hazard potential classification (ADNR 2005; Cobb 2014). The final TSF design would ultimately be capable of storing the full volume of the IDF above the normal operating pond, while maintaining 6.6 feet of freeboard without discharge (Table 3.5-25). This design is based on containing tailings plus an IDF corresponding to the 200-year snowmelt and runoff from a 24-hour PMP, which is assumed to occur at the end of the 200-year snowmelt with the ground fully saturated or frozen (BGC 2011a).

Figure 3.5-19 shows the average annual flow entering the TSF during the construction period. Runoff within the TSF catchment during construction would not be considered contact water and would be released to Anaconda Creek. Average annual runoff within the TSF catchment, including seepage from the north and south FWDDs (located upstream from the TSF), is shown on Figure 3.5-19. Diversion channels will be constructed to capture fresh water upslope from the TSF footprint, and discharged to Anaconda Creek below the TSF starter dam. The average annual flow in these diversion channels during the construction phase is shown on Figure 3.5-19.

North and South FWDDs. Two FWDDs will be constructed upstream of the TSF (Figure 2.3-18, in Chapter 2, Alternatives). Construction of these dams will be completed prior to completing construction of the TSF starter dam. The FWDDs will collect freshwater runoff from the upper reaches of the watershed that will be diverted around the TSF impoundment, minimizing the amount of water entering the TSF during construction and early operational years (BGC 2011a). Based on ADNR Dam Safety Guidelines, both the north and south Anaconda FWDDs would likely have a significant (Class II) hazard potential classification (ADNR 2005; Cobb 2014). The north and south Anaconda FWDDs are sized to contain the 100-year snowmelt (Table 3.5-25). The north FWDD would have a maximum storage capacity of 478 acre-feet, and the south FWDD would have a maximum storage capacity of 211 acre-feet (BGC 2011a). The north and south FWDDs have spillways that are designed to convey the 100-year peak instantaneous discharge of 113 cfs and 60 cfs, respectively (BGC 2011a).

The average annual flow from the Anaconda FWDDs that would be diverted around the TSF, TSF runoff, flow from diversion channels, runoff from undisturbed ground, and flow discharged to lower Anaconda Creek during the construction phase is shown on Figure 3.5-19. The average annual flow diverted to lower Anaconda Creek, and ultimately to Crooked Creek, is approximately 9 cfs during the construction phase.

Summary – Anaconda Creek. Substantial flow diversion and some water storage would take place within the Anaconda Creek watershed during the Alternative 2 construction phase, and would result in some reduction in watershed yield and a subsequent discharge to Crooked Creek that may or may not be within the historical seasonal variation. While the majority of runoff would be captured and diverted to lower Anaconda Creek during the construction phase, the construction of the starter dam, diversion channels, and FWDDS would result in substantial alterations to the watershed. Thus, the magnitude of the direct and indirect impacts on Anaconda Creek during the construction phase is expected to range from medium to high. As the impact of some of these operations will extend beyond the life of the project, the duration of the impact is expected to be permanent. Since water is being diverted from Crooked Creek and will have at least a small impact on Crooked Creek flows, but will probably have a negligible impact on the Kuskokwim River, the geographic extent of the impact is expected to be local to regional.

Snow Gulch

Under pre-mining conditions, Snow Gulch contributes about 3 to 11 cfs of flow to Crooked Creek in summer (Section 3.5.2.1.2). The Snow Gulch freshwater dam (FWD) constructed near the middle of the Snow Gulch watershed (Figure 3.5-18) would partially restrict this flow from reaching Crooked Creek. The Snow Gulch FWD would likely be considered a Class I or II, high or significant hazard dam (ADNR 2005; Cobb 2014). The FWD would store 3,243 acre-feet of fresh water with 3.3 feet of freeboard, with a spillway designed to convey the 100-year peak instantaneous flow (Table 3.5-25). Once the dam has reached maximum storage capacity, the spillway will be used until process plant start-up when a pipeline to the Lower CWD would be constructed. Water discharge through the spillway would enter Snow Gulch downstream of the dam using appropriate energy dissipation to minimize sediment entering the creek as a result of erosion.

Summary – Snow Gulch. Anticipated effects of mine development in the Snow Gulch watershed during the Alternative 2 construction phase would result in a reduction in watershed yield and subsequent discharge to Crooked Creek due to water diversion and storage. Since some water will pass through the overflow when the reservoir is full, the magnitude of the direct and indirect impacts on Snow Gulch is expected to be medium to high. Because the dam will be required during construction and operations, the duration of the impact is expected to be long-term. Since water is being diverted from Crooked Creek and will have at least a small impact on Crooked Creek flows, but will have a negligible impact on the Kuskokwim River, the geographic extent of the impact is expected to be local to regional.

Overburden Stockpiles

Overburden stockpiles would be developed during the construction phase for storage of excavated material that would be used during the reclamation phase of the tailings and waste rock facilities (SRK 2012b). Overburden stockpiles, shown on Figure 3.5-18, that would be located outside of areas that drain into proposed dams include:

- Northern Overburden (NOB) stockpile located in the Lewis Gulch watershed north of the open pit;
- Southern Overburden (SOB) stockpile located between Omega Creek and Unnamed Creek SE1 watersheds;
- Stockpiles 1 and 3 located downstream (west) of the TSF dam in the Anaconda Creek watershed; and
- Stockpile 2 located between Anaconda Creek and Unnamed Creek SE1 watersheds.

The NOB stockpile and Stockpiles 1, 2, and 3 would be managed by intercepting and directing surface runoff to sediment detention ponds in order to prevent sediment from entering Crooked Creek. These sedimentation ponds would be sized to contain the 10-year return period, 24-hour duration storm. Upslope diversion ditches would be constructed for each stockpile, and are designed to minimize runoff volumes requiring containment. The diversion channels would be sized for the 100-year peak instantaneous discharge (SRK 2012b). The NOB stockpile will be composed of organic materials and loess only, and it is assumed that precipitation that comes into contact with these materials will generate runoff and/or seepage flows suitable for discharge to the environment without treatment. The two ponds that are proposed to collect runoff from this material would be designed as sediment control structures, with release to the environment once the coarser sediment has settled out. During runoff events equal to or less than the runoff produced by a 10-year 24-hour precipitation event, no water would be released from the detention structures until adequate settling and suitable water quality criteria are met. The destination of excess water in the event of higher precipitation (e.g., pumping to a backup water containment structure such as the Lower CWD) would typically be addressed in SWPPP permitting. The stockpiles would be revegetated as they are developed in order to reduce sediment detention requirements, and would be surrounded by berms and/or gabions to prevent sloughing of material from the slopes into diversions and drainages and blocking flow.

The SOB stockpile is considered to be potentially metal leaching, and seepage and surface runoff that comes into contact with the SOB stockpile would be collected in a sediment detention pond and pumped to the Lower CWD (SRK 2012b). The affected area and subsequent drainage area associated with the SOB stockpile is 64 acres (BGC 2011j). The average annual rate of water pumped from the SOB stockpile detention pond to the Lower CWD during the construction period is shown on Figure 3.5-19. The SOB sedimentation pond would be sized to contain the 10-year return period, 24-hour duration storm. An upslope diversion channel, designed to collect runoff upslope of the SOB stockpile, would divert runoff directly to Unnamed Creek SE1 (Figure 3.5-18). The diversion channel would be sized for the 100-year peak flow (SRK 2012b). The SOB stockpile will be surrounded by berms and/or gabions to prevent sloughing of material from the slopes into diversions and drainages and blocking flow.

Summary – Overburden Stockpiles. Anticipated effects of overburden stockpile development during the Alternative 2 construction phase would result in a negligible reduction in average annual watershed yield and subsequent discharge to Crooked Creek due to water diversion and storage. Thus, the magnitude of the direct and indirect impacts on water quantity within Crooked Creek is expected to be low. Since the overburden stockpiles will be used throughout construction and operations, the duration of the impact is expected to be long-term. Because some water may be diverted from local drainages but the impact to Crooked Creek is probably negligible, the geographic extent is expected to be local; and since the impact would not affect a shared resource, the context of the impact is common.

Other Water Use and Construction Camp

Additional water use requirements for the project are described in Section 2.3.2 (Chapter 2, Alternatives). As discussed above, the majority of surface water within the mine site will be either diverted to Crooked Creek or stored for use in ore processing. Other water, such as potable water, fire protection water, and sanitary water would be pumped from groundwater wells. Untreated sanitary effluent from each building would be pumped via pipelines to the sanitary treatment plant, and treated effluent would be pumped to the Lower CWD during construction (SRK 2012c).

The anticipated effects of other water use during the Alternative 2 construction phase would likely result in a minor reduction in average annual watershed yield and subsequent runoff to Crooked Creek. Thus, the magnitude of the direct and indirect impacts of the other water use and construction camp on water quantity within Crooked Creek is expected to be low. Since the other water uses will extend through construction and operations, the duration of the impact is expected to be long-term. Because these water uses would primarily tap local groundwater supplies but could have a small effect on Crooked Creek, the geographic extent of the impact is expected to be local to regional.

<u>Operations and Maintenance</u>

Water Balance/Management

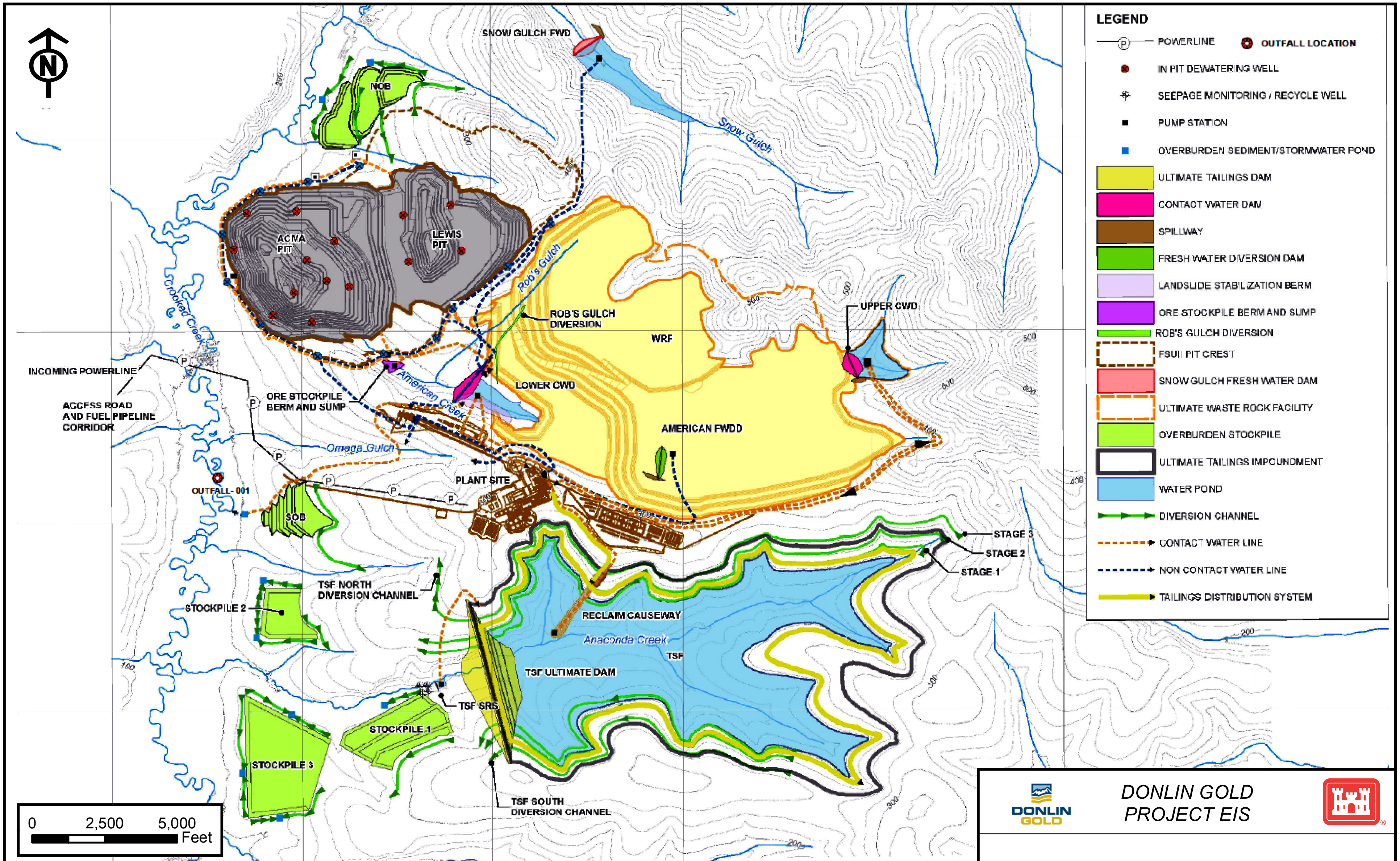
Water management during the operations period of 27 years includes surface water distribution, storage, and use within the mine site (Figure 3.5-20). The mine is designed for zero-discharge of untreated contact water during the life of the mine. An APDES permit would be obtained for the release of treated water from the water treatment plant to the Crooked Creek outfall. Water management strategies have been developed to achieve this design, maintain sufficient fresh water for ore processing during operations, and minimize the volume of water in the TSF at closure (SRK 2012b; BGC 2015c).

Water sources that would be managed and maintained to provide water as necessary to the process plant during operations include (SRK 2012b):

- TSF reclaim water;
- WRF runoff and in-pit dewatering water collected in the Lower and Upper CWDs;
- Perimeter pit dewatering groundwater;
- American FWDD (for the first year of operations); and
- Snow Gulch FWD, a contingency source of fresh water throughout operations.

During the operations and maintenance phase, and under average precipitation conditions, the mine is expected to operate with a water surplus (BGC 2015c). Surface water would be stored in the TSF pond until closure, at which point it would be pumped to the mine pit. Water management strategies that would limit excess water accumulation in the system include (SRK 2012b; BGC 2015c):

- The American FWDD would be used until the end of Year 1, when the process plant capacity reaches projected maximum values;
- Runoff to the TSF would be reduced by the FWDDs (maintained until the end of Year 3), and the construction of three diversion channels along the north and south sides of the facility;
- Groundwater from pit dewatering wells would either be treated and discharged to Crooked Creek, or pumped to the process plant for process water;



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Data Source: Donlin Gold 2012

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WATER MANAGEMENT PLAN DURING OPERATIONS

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FIGURE 3.5-20

- Runoff and drainage collected by the TSF SRS would be treated and discharged to Crooked Creek;Contact water impounded in the Lower and Upper CWDs would be treated and discharged to Crooked Creek at a maximum rate of 1,101 gpm;
- TSF pond water would be treated and released to Crooked Creek at an average rate of 132 gpm, and a maximum rate of 313 gpm; and
- Evaporative sprayers could be employed on the TSF to help reduce the build-up of pond volumes in excess of 5,680 acre-feet.

Stream Flow and Runoff Alterations

American Creek

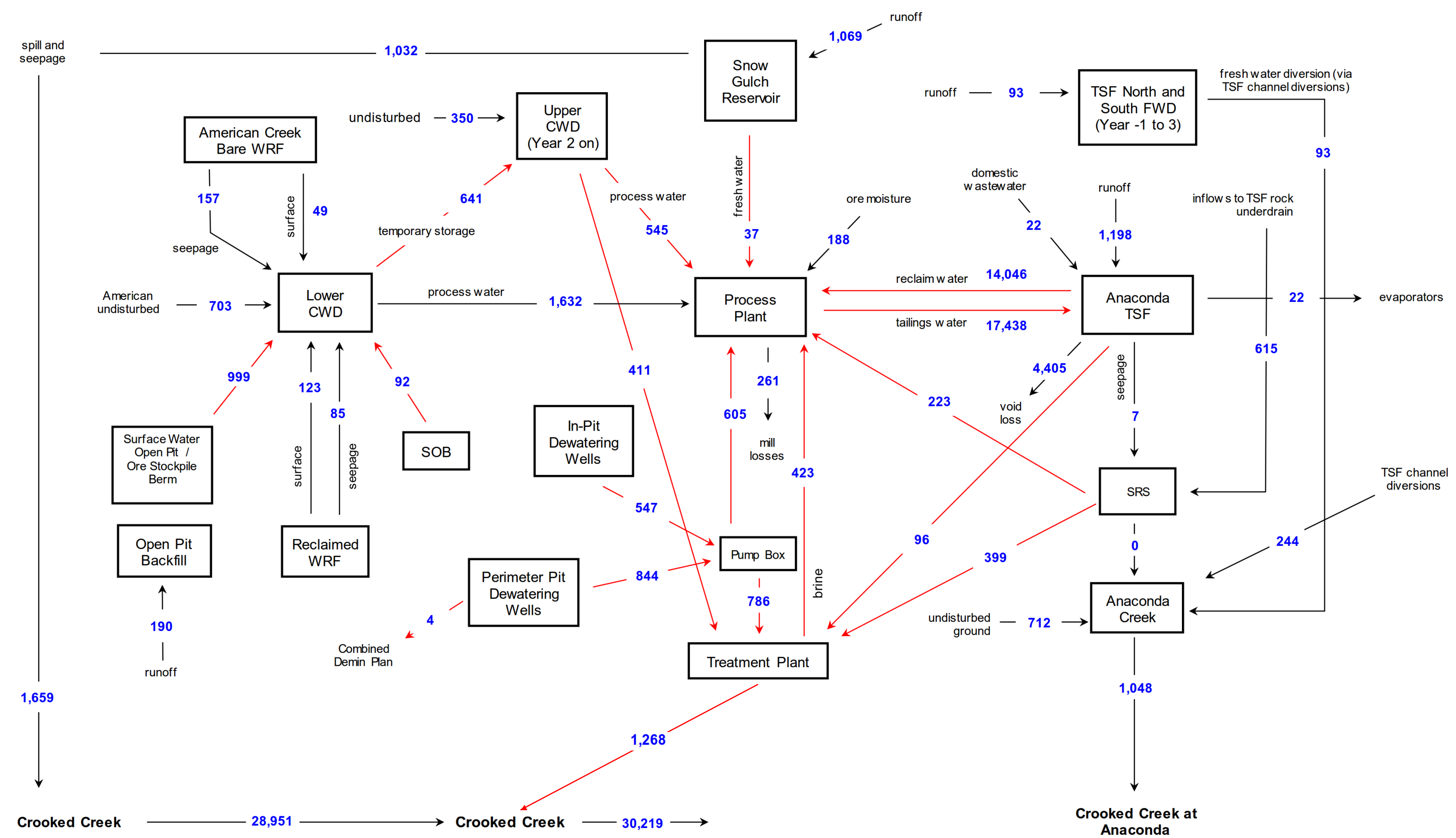
Activities that would affect water distribution and storage within the American Creek watershed and restrict the amount of water reaching Crooked Creek during the mine operations phase would include: construction of the Upper CWD, removal of the American FWDD, reclamation of the WRF, management of WRF bare ground runoff, mine pit development, mine pit groundwater dewatering, in-pit surface water transfer to Lower CWD, management of ore stockpile berm, and management of SOB stockpile runoff (Figure 3.5-20). Figure 3.5-21 presents the average annual flow for mine water supply and distribution within the American Creek watershed based on average precipitation conditions during mine operations (BGC 2014e).

Upper CWD. The Upper CWD would be located in the eastern portion of the American Creek watershed, upstream from the American FWDD (Figure 3.5-20). The Upper CWD would be constructed during the first year of operations to provide additional storage capacity for contact water. Based on ADNR Dam Safety Guidelines, the Upper CWD would likely have a significant (Class II) hazard potential classification (ADNR 2005; Cobb 2014). The dam is designed to store a maximum-sized pond of 3,240 acre-feet, with 3.3 feet of freeboard above the routed design flood and a spillway designed to convey the 24-hour PMF (Table 3.5-25).

The Upper CWD would receive runoff from undisturbed ground above the dam and contact water pumped from the Lower CWD through an above ground pipeline. Transferring water from the Lower CWD to the Upper CWD would serve to minimize wetting of the toe (lower end) of the WRF. The pipeline route would follow the southern edge of the WRF (Figure 3.5-20).

Water from the Upper CWD would be an additional source of process water during operations; therefore, a pipeline from the Upper CWD to the process plant would be constructed, following the same pipeline route along the southern edge of the WRF (SRK 2012b).

American Creek FWDD. During the first year of mine operation, the American FWDD would collect runoff from the upper American Creek watershed, reducing contact water accumulation in the Lower Contact Water Pond. When not needed for process water, this fresh water would be pumped to Crooked Creek via a pipeline installed along the southern American Creek ridgeline (Figure 3.5-18). When the stored volume behind the Lower CWD is less than 811 acre-feet, water from the FWDD would be transferred to the Lower CWD instead of being discharged to Crooked Creek (SRK 2012b). During the second year of mine operation, the FWDD would be regraded to allow for expansion of the WRF (SRK 2012b). The removal of the FWDD would reduce water being discharged to Crooked Creek.



Note: Red arrows denote pumping routes. Values shown are in gpm.
Note that all nodes do not balance, in particular the contact water dams and fresh water dam. These nodes do not balance as the dams either start with or end with a surplus of water.

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SCHEMATIC WATER BALANCE DURING OPERATIONS

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FIGURE 3.5-21

Data Source: BGC 2015f

WRF and Lower CWD. Development of the WRF is described in detail in Section 2.3.2 (Chapter 2, Alternatives). By the end of the first year of operations, WRF expansion would require removal of the FWDD. By the end of Year 6, the eastern extent of waste rock placement would reach the Upper CWD.

Waste rock would be contoured so that runoff would drain toward the southern toe of the WRF into a collection channel that would convey flow to the Lower CWD during operations, and then into the pit lake at the end of operations (SRK 2012b). After the waste rock is contoured, the WRF would be reclaimed progressively during mine operation with a cover consisting of a 13.8-inch layer of a peat-mineral mix (for vegetative growth) underlain by a 12-inch layer of terrace gravel and/or colluvium. Design permeability of the cover material is described in Section 3.2, Soils. The contouring would create drainages that would be maintained and protected with rip rap or cobble and boulder placement to ensure that cover integrity is maintained (SRK 2012b).

The WRF would ultimately cover an area of approximately 3.5 square miles, just over half of the American Creek watershed. During operations, the Lower CWD would receive water from the following sources: undisturbed watershed runoff; exposed (bare) WRF runoff and seepage; reclaimed WRF runoff and seepage; water pumped from the SOB stockpile detention pond; and surface water pumped from the open pit and ore stockpile berm (Figure 3.5-21). Water stored in the Lower CWD would either be pumped to the Upper CWD for temporary storage or used as process water.

Open Pit Surface Water, Dewatering Wells, and Ore Stockpile Berm. During the mine operations, surface water runoff and seepage collected in the open pit and at the ore stockpile berm would be pumped to the Lower CWD (Figure 3.5-21). This would account for roughly 45 percent of the total input to the Lower CWD during the operation period.

Groundwater would be pumped from both perimeter and in-pit dewatering wells during the life of the mine (Figure 3.5-20), which would be located primarily in the American Creek drainage. During mine operation, this water will be pumped into a pump box and either pumped to the process plant or to the water treatment plant for treatment and discharge to Outfall 001 on Crooked Creek (Figure 3.5-20). It is estimated that, during operations, an average of 1,268 gpm (2.8 cfs) would be treated and discharged to Outfall 001 on Crooked Creek (Figure 3.5-21).

Based on groundwater and surface flow modeling (see Section 3.6.2.2.1, Groundwater Hydrology), surface water flow reductions in Crooked Creek (at CCBO) as a result of pit dewatering and water diverted from American Creek are shown in Table 3.5-26. By Year 20 of mine operations under average flow conditions, the maximum flow reduction in Crooked Creek at CCBO would be 18 percent, which would occur during winter months. Under the same conditions, the average annual flow reduction at CCBO is predicted to be 10 percent. However, maximum flow reductions at CCBO could be as high as 95 percent in winter if certain conditions are present (e.g., higher hydraulic conductivities in bedrock and faults and low flow (drought) conditions in Crooked Creek) (BGC 2015h).

SOB Stockpile. Runoff and seepage collected in the SOB stockpile detention structure, located south of Omega Gulch would be pumped to the Lower CWD (Figure 3.5-20). The SOB stockpile is not located in the American Creek drainage; however, the runoff and seepage collected here represents additional flow (approximately 0.2 cfs) that would be diverted from Crooked Creek.

Summary – American Creek. Anticipated effects of mine operations in the American Creek watershed under Alternative 2 would result in little to no stream flow contribution to Crooked Creek from American Creek, due to captured runoff and seepage from the WRF footprint and undisturbed ground, ACMA pit expansion and dewatering, and the ore stockpile berm and sump (Table 3.5-26). Thus, the magnitude of direct and indirect impacts on water quantity within American Creek is expected to be high. The effect of this flow reduction on Crooked Creek is expected to be of medium to high magnitude, in that it may or may not be within historical variation in the summer, but could have substantial effects on low flow during winter. Since the impact of some of these operations would extend beyond reclamation, the duration of the impact is expected to be permanent. The effect of water being diverted from Crooked Creek is expected to extend for several miles downstream of the mine, but would be negligible on the Kuskokwim River; thus, the geographic extent of the impact would range from local to regional. Since the impact affects an abundant but shared resource (Crooked Creek) and one governed by regulation, the context of the impact would be common to important.

Anaconda Creek

Activities affecting water distribution and storage during mine operations within the Anaconda Creek watershed, and that restrict the amount of water reaching Crooked Creek, would include staged construction of north and south diversion channels, decommissioning of the TSF FWDDs after Year 3 of operation, and seepage collection downstream of the TSF impoundment (Figure 3.5-20). The average annual flow for mine water supply and distribution components used in the Anaconda Creek water balance (under average precipitation conditions) during mine operations is presented on Figure 3.5-21.

TSF and Seepage Recovery System (SRS). During the mine operations phase, the drainage area of the TSF will expand to approximately 3,755 acres, with a maximum storage capacity of 334,298 acre-feet (BGC 2011a). The final TSF facility would occupy roughly 75 percent of the Anaconda Creek watershed. The TSF would receive runoff from within the facility, domestic wastewater, and from tailings water. The average annual rate of runoff to the TSF from each source (under average precipitation conditions) during mine operations is presented on Figure 3.5-21. There would be approximately 1,074 acres of undisturbed watershed downstream from the TSF dam. Runoff from this area would enter lower Anaconda Creek at an average annual rate of 712 gpm (1.6 cfs).

The SRS would be located downstream of the TSF dam (Figure 3.5-20). The SRS would capture potential seepage from the lined TSF, seepage from the TSF dam, and surface water and groundwater flows that enter the rock drains beneath the TSF impoundment liner. The SRS would have a total storage capacity of 16.2 acre-feet (SRK 2012b). Water collected in the SRS would either be pumped to the process plant or to the water treatment plant (Figure 3.5-21). Ditches along the base of the TSF dam and adjacent to the SRS would be constructed to divert runoff from the dam face around the SRS. These ditches would be designed to convey the 200-year peak instantaneous flow (SRK 2012b).

North and South FWDDs. During the first 3 years of mine operations, the North and South FWDDs would collect runoff from undisturbed ground, providing a sizeable control on TSF impoundment volumes. The water levels behind the TSF FWDDs would be controlled by pumping water out of the FWDD ponds into respective diversion channels (Figure 3.5-20). In order to maintain sufficient storage for peak runoff events, the pond volumes in each FWDD would be kept at a minimum by pumping water into the diversion channels (SRK 2012b). Water collected behind each FWDD would be considered non-contact water and be diverted to lower Anaconda Creek at an average annual rate of 93 gpm (0.2 cfs) (Figure 3.5-21). After Year 3 of operation, the TSF FWDDs would be decommissioned. The north and south diversion channels would remain in place to capture and divert runoff from undisturbed ground north and south of the TSF.

North and South Diversion Channels. Diversion channels, located along the north and south sides of the TSF, would be constructed in three stages (Figure 3.5-20). The first stage would be constructed during the construction phase, and the second and third stages would be constructed during the operations and maintenance phase. These channels would be designed to convey the 200-year peak instantaneous flow (SRK 2012b). During the first 5 years of operations, the drainage areas above the north and south diversion channels would be 939 acres and 395 acres, respectively. The final stage of the diversion channels would be constructed by Year 10 of operation, and the drainage areas above the north and south diversion would reduce to 618 acres and 148 acres, respectively. Channel diversions are not feasible after Year 17 as TSF expansion would approach the confining ridges of the Anaconda Creek watershed (SRK 2012b).

The water conveyed in the diversion channels is from undisturbed ground, and would be considered non-contact water. Both diversion channels will discharge into Anaconda Creek, downstream of the TSF dam (Figure 3.5-20). The first and second stage of the north diversion channel would be discharged into a well-defined tributary located on the north side of Anaconda Creek. This tributary channel becomes poorly defined half-way up the slope; therefore, the third stage of the north diversion channel would be routed north into the Unnamed SE1 Creek watershed (Figure 3.5-20). To minimize erosion of the valley slopes, flow from the north diversion channel would be conveyed through either a High Density Polyethylene pipe, half-pipe, or armored channel (SRK 2012b). The south diversion channel would discharge into a well-defined tributary on the south side of Anaconda Creek for all three stages, and channel protection (armoring) of this tributary would be evaluated during final design. The combined average annual flow from the diversion channels during the mine operations phase is shown on Figure 3.5-21.

Summary – Anaconda Creek. The ultimate TSF footprint would occupy approximately 70 percent of the Anaconda Creek watershed. Anticipated effects of mine operations in the Anaconda Creek watershed under Alternative 2 would result in substantial flow diversions and water storage within Anaconda Creek. As shown in Table 3.5-26, under average flow conditions, Anaconda Creek average annual flow could be reduced by as much as 67 percent during the operations and maintenance phase (BGC 2015h). The variation in stream flow from the normal watershed yield is likely to exceed the historic seasonal variation. Thus, the magnitude of direct and indirect impacts on the Anaconda Creek watershed is expected to be high. The effect of this flow reduction on Crooked Creek is expected to be of low to medium magnitude, in that it may or may not be within historic seasonal variation. Since the impacts will continue beyond the life of the mine, the duration of the impact is expected to be permanent. Because the impacts would affect hydraulically connected waters (Crooked Creek) within and beyond the Project Area, but not affect the Kuskokwim River, the geographic extent of the impact would range from local to regional. Since the impacts affect an abundant but shared resource (Crooked Creek), and one that is governed by regulation, the context is considered common to important.

Snow Gulch

The Snow Gulch FWD would be a contingency source of fresh water for the process plant during mine operation. The drainage area above the Snow Gulch FWD would be approximately 1,557 acres (SRK 2012b). Except when water is being withdrawn for use as process water, the FWD would be kept at its maximum capacity such that the spillway would be used on a continuous basis. The average annual runoff into the FWD and the amount of water pumped from the FWD to the process plant are shown on Figure 3.5-21. The average annual flow conveyed through the spillway to lower Snow Gulch would be approximately 1,032 gpm (2.3 cfs) (Figure 3.5-21). Water discharged through the spillway would enter Snow Gulch downstream of the dam using appropriate energy dissipation to minimize erosion and thereby minimize the amount of sediment entering the creek.

Summary – Snow Gulch. Anticipated effects of mine development in the Snow Gulch watershed during the mine operations and maintenance phase of Alternative 2 would result in an average of 14 percent reduction (higher under drought conditions when more water would be required from the Snow Gulch reservoir) in watershed yield and subsequent discharge to Crooked Creek due to water diversion and storage. Thus, the magnitude of the direct and indirect impacts on water quantity within Snow Gulch could range from low to high. The impact on stream flow will continue throughout mine operation but will be eliminated after reclamation of the mine and natural streamflow in Snow Gulch is restored; thus, the duration of the impact is expected to be long-term. Since some water is being diverted from Crooked Creek and will have at least a small impact on Crooked Creek flows, but will have a negligible impact on the Kuskokwim River, the geographic extent of the impact is expected to be local to regional. Because the impacts affect an abundant but shared and regulated resource (Crooked Creek), the context of the impact is considered common to important.

Above and Below Average Precipitation

Surface water management during mine construction and operations is designed to prevent the discharge of contact water from the WRF, mine pit, and TSF. Additionally, the Water Management Plan (SRK 2012b) limits the accumulation of excess water in these facilities. The previous descriptions of water management and estimated flow rates of diverted water were based on average precipitation conditions. Water management considerations for above and below average precipitation conditions are described below.

Above Average Conditions. In the above average precipitation scenario, the average annual precipitation would be 20.8 inches (SRK 2012b). Above average precipitation conditions during mine operations would increase the potential for excess water to accumulate in contact water dams and in the TSF. The following operational rules are designed to manage water during the mine operations and maintenance phase in order to maintain maximum operational pond volumes and limit accumulation of excess water (SRK 2012b):

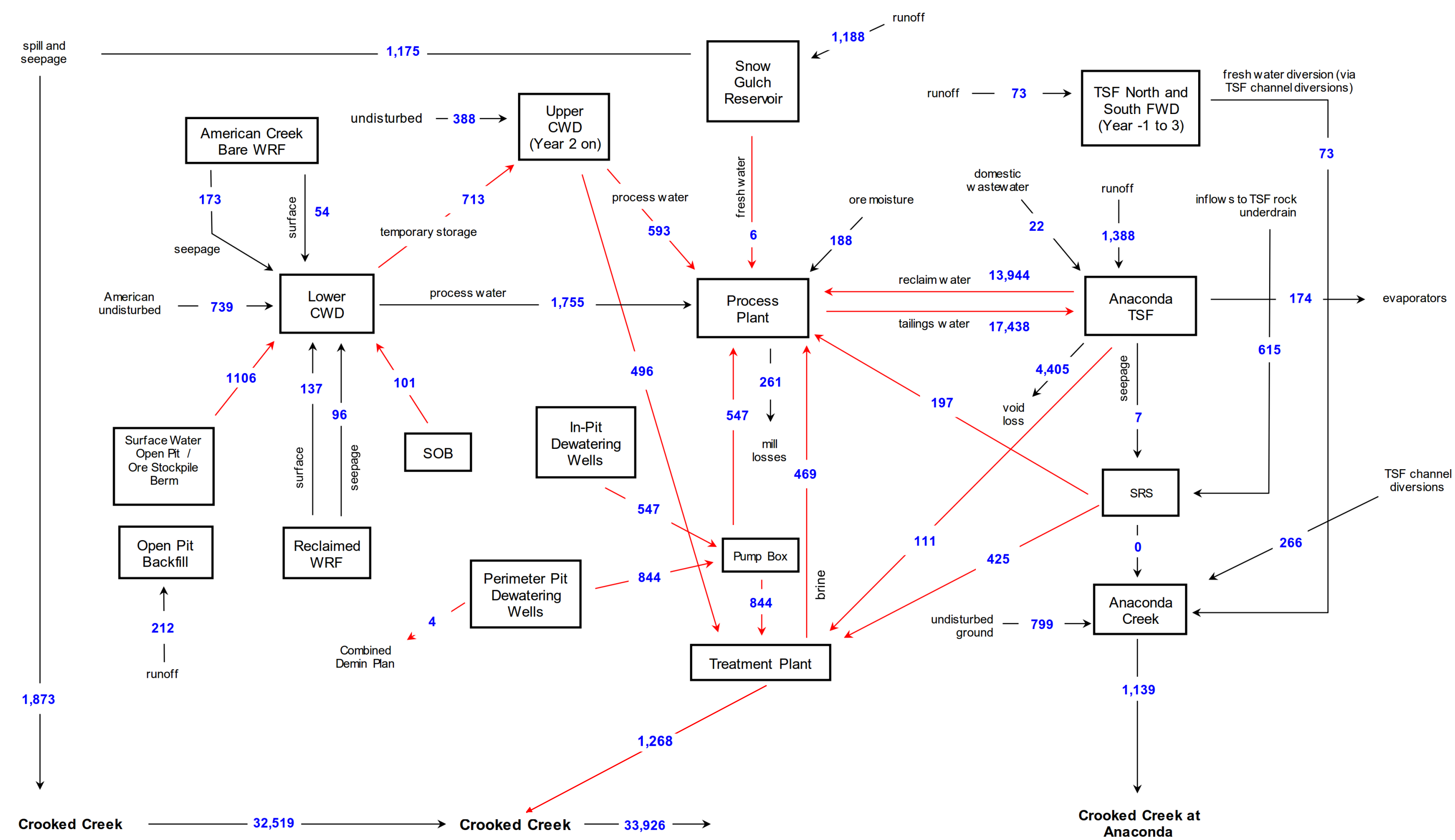
- Transfer of TSF reclaim water to the process plant would be maximized, although TSF impoundment volumes would temporarily increase;
- Runoff to the Upper and Lower CWDs, combined with mine pit dewatering groundwater, would satisfy fresh water requirements for the process plant and fresh water from the Snow Gulch FWD would not be required;

- Runoff to the Snow Gulch FWD in excess of storage capacity (3,243 acre-feet) would be discharged through its spillway;
- During operational years 1 to 3, runoff to the TSF FWDDs would be pumped to the diversion channels and discharged to Anaconda Creek downstream of the TSF dam and SRS;
- When the Lower CWD pond volume exceeds 284 acre-feet, contact water would be pumped to the Upper CWD at a maximum pumping rate of 6,605 gpm for temporary storage;
- When the combined Upper and Lower CWD pond volumes exceed 1,460 acre-feet, groundwater pumped from the pit perimeter and in-pit dewatering wells and inflows to the TSF SRS would be sent to the water treatment plant and discharged to Crooked Creek at Outfall 001;
- When the combined Upper and Lower CWD pond volumes exceed 1,860 acre-feet, CWD water is pumped to the water treatment plant at a maximum rate of 1,101 gpm where it is combined with the other sources of water for treatment. Treatment of TSF pond water commences at this time at an assumed average rate of 220 gpm; and
- When the combined Upper and Lower CWD pond volumes exceed 2,920 acre-feet, the entire process water demand (fresh and non-fresh water) would be pumped from the CWD ponds to the process plant; the TSF reclaim water would not be pumped to the process plant during these conditions.

The procedures listed above would maintain maximum operational pond volumes of 811 acre-feet and 3,240 acre-feet in the Lower and Upper CWDs, respectively. Storage capacity in the Lower CWD would also be maintained in the event of the PMP occurring under these maximum conditions; however, waste rock in the WRF would be inundated (SRK 2012b). The water balance schematic of predicted average annual flow rates for each mine component during operations under above average precipitation conditions is shown on Figure 3.5-22.

Below Average Conditions. In the below average precipitation scenario, the average annual precipitation would be 18.6 inches (SRK 2012b). If below average precipitation conditions occur during the operations and maintenance phase, the fresh water requirement for the process plant would likely exceed runoff into the Upper and Lower CWDs. The water balance schematic of predicted average annual flow rates for each mine component during operations under below average precipitation conditions is shown on Figure 3.5-23. The following procedures are designed to manage water during the mine operations and maintenance phase in order to maintain fresh water demands for the process plant (SRK 2012b):

- TSF reclaim water would be used for process water, and
- Fresh water from the Snow Gulch FWD would be used for process water.



Note: Red arrows denote pumping routes. Values shown are in gpm.
Note that all nodes do not balance, in particular the contact water dams and fresh water dam. These nodes do not balance as the dams either start with or end with a surplus of water.

Data Source: BGC 2015f

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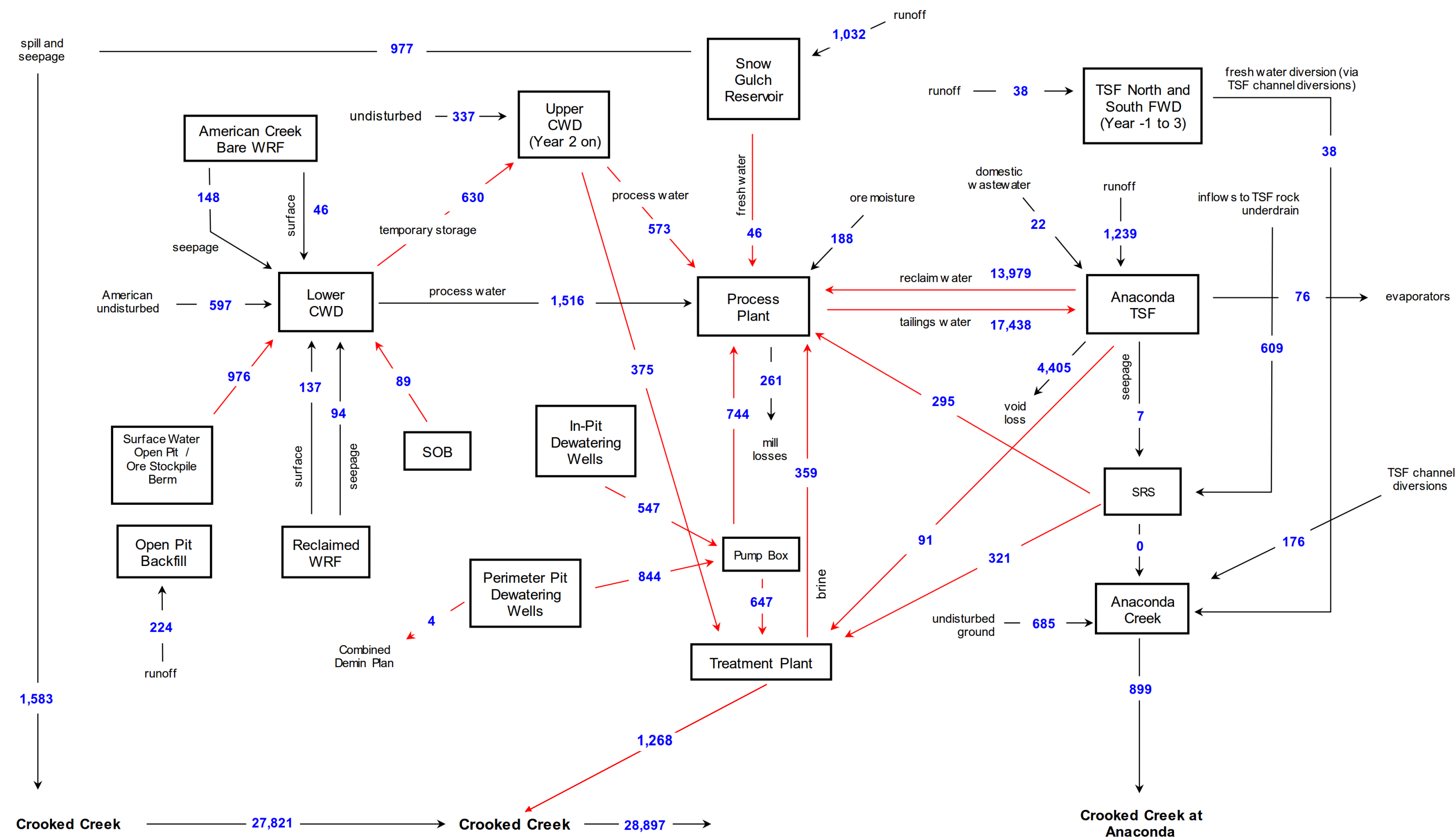
SCHEMATIC WATER BALANCE: ABOVE AVERAGE PRECIPITATION DURING OPERATIONS

NOVEMBER 2015

FIGURE 3.5-22



Note: Red arrows denote pumping routes. Values shown are in gpm.
Note that all nodes do not balance, in particular the contact water dams and fresh water dam. These nodes do not balance as the dams either start with or end with a surplus of water.

Data Source: BGC 2015f

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SCHEMATIC WATER BALANCE: BELOW AVERAGE PRECIPITATION DURING OPERATIONS

NOVEMBER 2015

FIGURE 3.5-23

Mine Site Facilities Runoff

The process plant would be located on the ridge between American Creek and Anaconda Creek (Figure 3.5-20). Surface runoff from precipitation and snowmelt generated from the plant facility would be considered contact water and would therefore be diverted to the TSF (SRK 2012b). Drainage from the plant site would be controlled to prevent discharge into the TSF north diversion channel, located downstream from the process facility. Surface runoff from the plant site would be directed into a culvert constructed under the TSF north diversion channel and access road to the TSF, and discharged into the TSF impoundment.

Other facilities at the mine site include the crusher facility, truck shop, and fuel storage area (Figure 2.3-6 in Chapter 2, Alternatives). Precipitation and snowmelt runoff from these facilities would drain to the Lower CWD.

Runoff diversion from the mine facilities under Alternative 2 would result in a limited reduction in watershed yield and would probably result in changes to flow that are within the limits of historic seasonal variation. Therefore, the magnitude of the direct and indirect impacts on water quantity is expected to be low. The diversion of runoff would last through the mine operations and maintenance phase and thus, the duration of the impact is expected to be long-term. Since the impacts of the diversion are limited to discrete portions of the Project Area, the geographic extent of the impact is expected to be local.

Effects on Crooked Creek

During operation of the mine, surface runoff and groundwater seepage in many parts of the Project Area will be diverted and/or captured (i.e. stored). Once captured, this water will be entrained in the tailings; or lost to the atmosphere through surface evaporation, use in the mill, or use in the power plant (BCG 2015c, h). Regardless of its final use or consumption, the loss of this water will reduce the runoff that would normally reach surface waters in the Project Area.

The effects of damming, pit dewatering, and other diversions at the mine site on flow in Crooked Creek could vary widely depending on season, precipitation conditions, bedrock hydraulic conductivity (K), phase of mine operations, and distance from the mine. Predicted maximum average monthly stream flow reductions and average yearly stream flow reductions, at various locations on Crooked Creek and at the mouth of American and Anaconda creeks, are presented in Table 3.5-26 (BGC 2015h). Reduction estimates are presented for Years 10 and 20 of operations, based on both the average stream flow condition (i.e. 50 percent stream flow condition) and the 10th percentile stream flow condition, and for both an anticipated hydraulic conductivity condition and a high hydraulic conductivity of the bedrock aquifer condition (BGC 2014c).

Year 20 is anticipated to represent the maximum impact on Crooked Creek stream flows. The ACMA pit is anticipated to be at its maximum depth by Year 20 and the pit footprint is anticipated to be at its maximum extent. As a result, runoff from the American Creek watershed captured by the pit and Lower CWD, and Crooked Creek flow intercepted by pit dewatering are at their greatest in Year 20. Beyond Year 20, less Crooked Creek flow is intercepted as a result of pit backfilling and the ending of pit dewatering. This will allow the water table at the base of the pit to start to recover (i.e. increase in elevation). An increase in the water table elevation at the pit reduces the hydraulic gradient between Crooked Creek and the pit, resulting in gradually reduced capture of Crooked Creek flows.

The estimates shown in Table 3.5-26 are based on an integration of a stochastic analysis of the site-wide water balance model (average flow and 10th percentile flow) and the MODFLOW groundwater model (anticipated K and high K) (BGC 2015h). The site-wide WBM was used to calculate stream flow impacts due to flows being captured in the American Creek and Anaconda Creek watersheds, as well as perimeter pit and in-pit groundwater being treated and released to Crooked Creek. The groundwater model was used to calculate the amount of Crooked Creek baseflow intercepted by the pit dewatering. The models indicate the following range of stream flow results (Table 3.5-26):

- For average flow and K conditions at locations on Crooked Creek that are downstream from American Creek, average yearly flow would be reduced by 4 to 17 percent during operations. The predicted maximum reduction in the monthly average flow, which would occur during one of the winter months of January through March, varies from 7 to 23 percent.
- For the 10 percent flow condition with an average K, at locations on Crooked Creek that are downstream from American Creek, the average yearly flow would be reduced by 5 to 22 percent during operations, and the predicted maximum reduction in the monthly average flow would vary from 9 to 33 percent.
- Under average K and average-to-dry precipitation conditions, the greatest flow reduction experienced near the mouth of Crooked Creek (at Bell Creek about 8 miles downstream of the mine) is projected to range from 4 to 10 percent.
- For average flow conditions and a high K condition of the bedrock aquifer, at locations on Crooked Creek that are downstream from American Creek, the average yearly flow would be reduced by 5 to 31 percent during operations. The predicted maximum reduction in the monthly average flow would vary from 16 to 67 percent.
- For the 10 percent flow condition with a high K condition, at locations on Crooked Creek that are downstream from American Creek, the average yearly flow would be reduced by 7 to 46 percent. The predicted maximum reduction in the monthly average flow would vary from 28 to 100 percent. Under these conditions, flow reductions in the vicinity of the mine site during winter months could result in Crooked Creek freezing to the bottom between American Creek and Omega Gulch, with much of the flow restored below Crevice Creek (28 to 40 percent reductions) due to tributary inflows. Potential impacts to fish and aquatic habitat resulting from reduced flow during winter conditions are described in Section 3.13, Fish and Aquatic Resources.

If the hydraulic conductivity of the bedrock aquifer is as anticipated by BGC (2014c, 2015h), the variation in Crooked Creek stream flow is likely to be within the magnitude of historical seasonal variations, but may have a longer duration than historical variations. If the hydraulic conductivity of the bedrock aquifer is higher than anticipated by BGC, the variation in Crooked Creek stream flow may exceed the magnitude of historical seasonal variations and may have a longer duration than historical variations. Thus, the magnitude of direct and indirect impacts is anticipated to range from low to medium, but would likely be up to a high magnitude in winter or if a high hydraulic conductivity conditions exists.

Table 3.5-26: Summary of Percent Reduction for Various Scenarios During Mining

	Percent Reduction in Stream Flow															
	Average Flow Condition				10th Percentile Low Flow Condition				Average Flow - High K Condition				10th Percentile Low Flow - High K Condition			
	Year 10 of Mining		Year 20 of Mining		Year 10 of Mining		Year 20 of Mining		Year 10 of Mining		Year 20 of Mining		Year 10 of Mining		Year 20 of Mining	
	Max Month	Avg. for Year	Max Month	Avg. for Year	Max Month	Avg. for Year	Max Month	Avg. for Year	Max Month	Avg. for Year	Max Month	Avg. for Year	Max Month	Avg. for Year	Max Month	Avg. for Year
American Cr.	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100
Crooked Cr. at American Cr.	-20	-15	-23	-17	-28	-19	-33	-22	-60	-28	-67	-31	-100	-44	-100	-46
Crooked Cr. below Omega Gulch (CCBO)	-16	-8	-18	-10	-22	-10	-25	-11	-47	-12	-52	-17	-85	-16	-95	-24
Anaconda Cr.	-73	-67	-73	-67	-74	-70	-74	-70	-73	-67	-73	-67	-74	-70	-74	-70
Crooked Cr. Below Anaconda Cr. (CCBA)	-20	-12	-22	-14	-26	-14	-29	-16	-49	-16	-54	-21	-85	-21	-94	-27
Crooked Cr. at Crevice Cr.	-18	-11	-20	-13	-23	-13	-26	-14	-45	-15	-49	-19	-76	-19	-85	-25
Crooked Cr. at Getmuna Cr.	-9	-5	-10	-6	-11	-6	-12	-7	-21	-7	-23	-9	-36	-9	-40	-12
Crooked Creek at Bell Cr.	-7	-4	-7	-5	-9	-5	-10	-5	-16	-5	-18	-7	-28	-7	-31	-9

Notes:
1 This table is summarized from data presented in BGC 2015h.
2 This table shows the reduction in flow from the pre-mining condition.
3 K = hydraulic conductivity of the bedrock aquifer
4 A minus sign (-) means there is a flow reduction due to mining. A plus sign (+) means the flow is higher during mining than prior to mining.

Potential impacts to Crooked Creek resulting from a reduction in streamflow could include changes to channel dimensions, as well as changes aquatic and fish habitat (see Section 3.13, Fish and Aquatic Resources). An alluvial river adjusts its channel dimensions to accommodate the range of flows that mobilize its bed and banks. For many rivers and streams, it has been observed that a single representative discharge may be used to characterize the width and depth of the channel. This representative channel-forming (or dominant) discharge is sometimes referred to as the bankfull discharge, the 1.5-year return period discharge, or the effective discharge.

Emmett (1972) developed a series of regression equations to estimate the width, average depth, bankfull cross sectional area, and bankfull water velocity based on the bankfull discharge. Because the magnitude of the bankfull discharge is strongly correlated to the size of the drainage area, Emmett was also able to develop a similar set of regression equations based on drainage area. Using data collected by the U.S. Geological Survey, Emmett developed equations for the both the Yukon and South-Central Regions of Alaska.

To estimate the likely magnitude of the impact that a reduction in Crooked Creek discharge might have on the bankfull channel dimensions immediately below the proposed Donlin mine, Emmett's equations were used to estimate the likely average channel dimensions before and after a reduction in flow (Aldrich 2015). For simplicity, it is assumed that unit runoff throughout the Crooked Creek watershed is the same, and that as a result of mining, no water would drain from or through the 17.5 square miles occupied by the mine.

The results of the computations are presented in Table 3.5-27 and indicate that the maximum likely change in the channel dimensions is as follows:

- The bankfull width will probably change by less than 8 percent.
- The bankfull average depth will probably change by less than 5 percent.
- The bankfull cross sectional area will probably change by less than 12 percent.
- The bankfull water velocity will probably change by less than 3 percent.

These estimates indicate that the maximum likely change is likely to be on the order of the natural variability along a relatively short reach of channel. The estimates are considered to be "worst-case" because it is likely that some water will pass from the area associated with the mine, particularly during periods of higher (channel forming) discharges. Thus, the magnitude of the direct and indirect impacts to channel geometry is anticipated to be low, the duration permanent, and the geographic extent local.

Streamflow and channel geometry (obtained from cross-sectional data from discharge measurements) would be monitored at select locations during mine operations. However, there would be no additional mitigation measures to adjust Crooked Creek to its altered flow regime given that the magnitude of impacts to the channel is anticipated to be low. Release of treated water from the water treatment plant during winter months was considered; however, it was determined that water would be needed for process water during the low flow winter months. Water management strategies related to the release of treated water take into account the need to avoid buildup of excess water, improved water treatment, and mitigate stream flow reductions.

Table 3.5-27: Summary of Channel Dimension Computations for Crooked Creek above Crevice Creek

Parameter	South-Central Region Equations		Yukon River Region Equations		Percent Change	
	Before Mine	After Mine	Before Mine	After Mine	S.C.R. Eq.	Y.R.R. Eq.
Drainage Area (square miles):	112	94.5	112	94.5	15.6	15.6
Bankfull Width (ft):	86.7	79.9	73.2	68.1	7.8	7.0
Bankfull Depth (ft)	2.8	2.7	4.4	4.3	5.0	4.0
Bankfull Cross Sectional Area (ft)	233.1	204.5	323.4	288.6	12.3	10.8
Bankfull Velocity (ft)	4.9	4.7	3.5	3.5	3.3	2.0

Notes:
**S.C.R. = South-Central Region; Y.R.R. = Yukon River Region.

Closure, Reclamation, and Monitoring

Water Balance

A mine water balance was developed for the closure and post-closure period of the mine based on the mine layout presented on Figure 3.5-24. The water balance indicates that during closure and post closure, stream flow in the Project Area would generally continue to be less than the stream flow prior to mining. The average annual flows during closure and post closure, from various mine components, are shown on Figure 3.5-25 through Figure 3.5-28. A summary of the anticipated stream flow reductions is presented in Table 3.5-26.

Stream Flow and Runoff Alterations

American Creek

During closure, the following surface water related activities would occur in the American Creek watershed.

- The WRF would be covered with a layer of colluvium or terrace gravel and then a layer of peat / organic material.
- The Lower CWD would be breached, the liner and fill material would be removed, and to the maximum extent practical, the surface would be restored to its pre-mining condition.
- The Upper CWD liner would be removed, and the impoundment would be filled with waste rock, graded, and reclaimed as part of WRF reclamation. Drainage from the backfilled and reclaimed areas would be graded to drain toward surface water collector channels constructed on the WRF as part of reclamation.
- The Rob's Gulch diversion would be left in place; however, permanent drainage of the WRF would rely on the valley bottom rock drains and not the diversion structure.
- The Ore Stockpile Berm and sump would be regraded and, to the maximum extent possible, restored to its pre-mining condition.

- Surface and seepage runoff from the WRF would be segregated and seepage flows would be piped to the bottom of the mine pit.
- Excess TSF water would be pumped into the mine pit.
- The WRF dump haul roads and ramps, and the long-term stockpile area would be rehabilitated.
- The majority of the runoff from the American Creek Watershed would be passed through the 4.14 mile long collection channel, constructed along the south margin of the WRF, to the pit lake.
- The drainage area of the American Creek watershed would increase from 6.9 to 7.8 acres, due to the ultimate pit footprint extending beyond the original watershed boundary (BGC 2015h).
- During the six month WTP operation period, treated water from the pit lake WTP would be released into the pit lake spillway channel (lower American Creek).

Due to the progressive reclamation of the WRF during mine operations, the majority of the WRF is expected to be reclaimed at closure. Once the WRF is completely reclaimed, the runoff coefficient for the reclaimed WRF is anticipated to be less than the runoff coefficient for the pre-mining condition and thus, the runoff from this area is anticipated to be less during closure and post closure than it was prior to mining.

Runoff that has not contacted waste rock would be routed to prevent contact with the waste rock, and discharged directly into Crooked Creek. However, this would represent only a fraction of the previous watershed and thus, only a fraction of the pre-mining flow.

The WRF seepage flows would be isolated by constructing four concrete containment structures at the rock drain outlets for American Creek and Rob's Gulch (Figure 3.5-24). Seepage collected in the containment structures would be diverted to the bottom of the pit lake through a gravity-fed pipe. The average annual seepage runoff conveyed through the gravity-fed pipe from the reclaimed WRF to the ACMA pit after mine operation is shown on Figure 3.5-25.

Pit Lake

At the time mining in the ACMA Pit ends, an emergency spillway will be constructed, dewatering will stop and the ACMA Pit will start to fill with water from direct precipitation, surface runoff, and groundwater inflow. Mining and dewatering in the Lewis Pit will continue for 2 more years, and mine operation on the stockpiled ore will continue for an additional 2 years after mining in the Lewis Pit ends. After the mill has stopped being used, the pit lake will receive approximately 8,190 acre-feet of supernatant pond water pumped from the TSF (BGC 2015h). As tailings in the TSF consolidate an additional 13,193 acre-feet of void water will be pumped to the pit lake over approximately a 52-year period (BGC 2015h). During this approximately 52-year period, water that infiltrates the TSF reclamation cover will also be pumped to the pit lake.

If left uncontrolled, the pit lake would eventually fill to the point of discharging through the emergency spillway to Crooked Creek. However, modeling of the pit lake geochemistry indicates that during and after filling, the pit water will exceed water quality standards and will need to be treated prior to discharge (Section 3.7, Water Quality). Therefore, to prevent a discharge from the pit lake, water from the pit lake will be pumped to an advanced water treatment plant and then discharged to Crooked Creek throughout the closure and post-closure period. Pumping will be required in perpetuity to ensure that hydraulic containment of contact groundwater and pit water is maintained, and that lake levels do not overtop the banks of the pit lake (Sections 2.3.2.1.12, Alternatives; and 3.6, Groundwater Hydrology).

The water treatment plant is anticipated to have an average annual operating period of approximately 6 months per year, and would be designed for a maximum capacity of 7,486 gpm. The capacity of the plant would allow treatment of the predicted annual pit inflow and thus, maintenance of the operational water level in the pit (BGC 2015h).

The operational water level in the pit would include sufficient freeboard to provide storage for upset flood events and also to prevent the development of a groundwater gradient from the pit lake towards Crooked Creek. The advanced water treatment plant would begin to operate when the water surface in the pit lake is approximately 33 feet below the low point of the emergency spillway. It is anticipated that the water surface in the pit lake will reach this elevation in about Year 51 of mine closure (BGC 2015h).

The impact on flows in Crooked Creek will be greater while the pit lake is filling than after the operational water level has been reached, because there will be no discharges from the pit during this period. Once the discharges from the pit begin, Crooked Creek flows will continue to be reduced from the pre-mining condition, but will be less reduced than during mining or while the pit is filling to the operations level (see Crooked Creek discussion below).

The emergency spillway would be constructed in the west corner of the pit and discharge to Crooked Creek (Figure 3.5-24). The spillway would be designed to convey the PMF and to prevent fish passage from Crooked Creek into the pit lake (SRK 2012b). In the event that pumping was interrupted, it is estimated that the length of time it would take for the pit lake to fill from the typical annual beginning of runoff elevation (i.e. about elevation 328 feet) to the spillway crest elevation (i.e. about elevation 359 feet) would be about 6 years, assuming average precipitation conditions (BGC 2015l). Put another way, the storage volume available between an elevation of 328 feet and an elevation of 359 feet is sufficient to contain the runoff from the PMP 24-hour precipitation, plus the runoff from the 100-year annual wet year plus the runoff from 3 average precipitation years, assuming the pumping operation is not restored. Because this would allow more than adequate time for the pumping system or water treatment plant to be repaired, even allowing for a combination of extreme events, a discharge to Crooked Creek through the emergency spillway from the mine pit lake is considered to be very unlikely. Thus, adverse impacts to Crooked Creek are not expected since the pit lake freeboard, the pumping system, and the advanced water treatment plant would be adequate to prevent overflow to Crooked Creek during the expected range of conditions.

Anaconda Creek and TSF

During closure, the following surface water related activities will occur in the Anaconda Creek watershed.

- TSF pond water would be pumped to the mine pit lake during the first year of closure.
- Water collected in the SRS would be pumped to the mine pit lake.
- The TSF would be covered with non-metal leaching/non-potentially acid generating rockfill material to provide a capillary break. The rockfill would be covered by a layer of colluvium, and then a peat/organic cover.

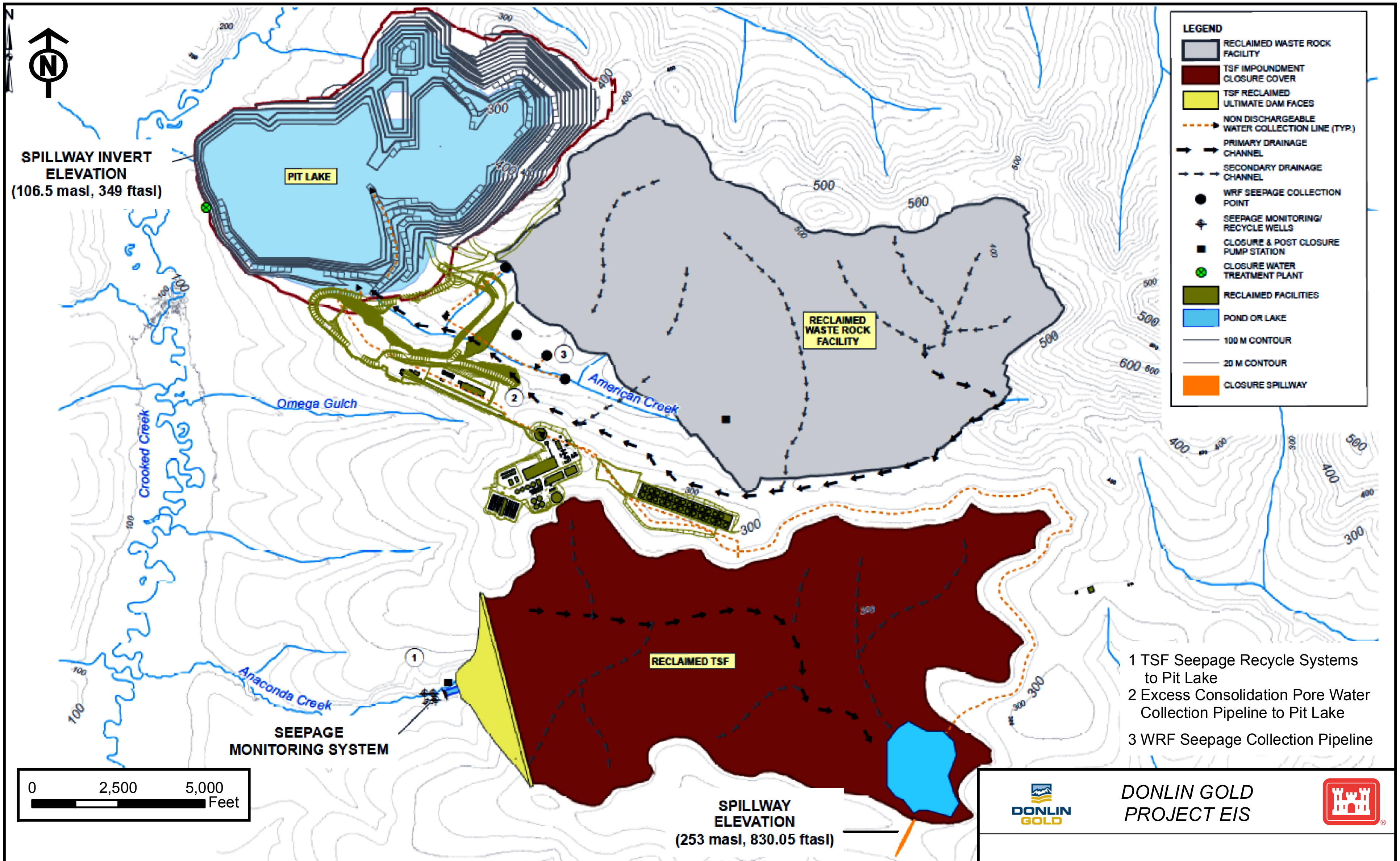
- A water collection system would be designed to collect water from the rock fill layer of the TSF cover, including excess tailings consolidation water and water infiltrating the TSF cover. This excess pore water would be kept separate from the cover runoff water and pumped back to the mine pit until consolidation is essentially complete, or until water quality monitoring results indicate discharge of this water to Crevice Creek is acceptable.
- The TSF surface would be contoured and a spillway excavated in the southeast end of the facility to direct runoff from the reclaimed TSF surface into Crevice Creek once it is considered suitable for discharge.

Closure Years 1 to 5. The TSF area would be reclaimed over a period of 5 years. It is estimated that the volume of water in the TSF impoundment at closure would be 14,950 acre-feet (SRK 2012b). The TSF water would be pumped to the mine pit lake during the first year of closure. After the TSF water is pumped out, the tailings surface would be allowed to dry, although pumping would continue for incoming runoff onto the tailings surface. During the next 4 years, one quarter of the tailings surface would be progressively reclaimed each year with the cover material. The average annual surface runoff from the TSF during the first 5 years of reclamation that would be pumped to the ACMA pit lake is shown on Figure 3.5-25.

Closure Years 6 to 51. Between closure Years 6 to 51, pumping from the SRS and TSF to the mine pit lake would continue as the tailings consolidate. This void water would be pumped from a rock fill layer that would create a capillary break between the tailings and cover (SRK 2012b). It is estimated that the total volume of void water released from the tailings during closure would be 13,193 acre-feet. The average annual volume of void water and cover infiltration pumped from the TSF to the mine pit lake between closure Years 1 and 51 is shown on Figure 3.5-25 through Figure 3.5-28.

Consolidation is assumed to be completed by the end of Year 51, and no further pumping would be required. Consolidation occurs when pore water is expelled from a saturated soil (tailings in this case), resulting in a densification and a volume reduction in the tailings. Since the movement of the pore water depends on the tailings permeability, which in turn depends on the density of the tailings, the rate at which consolidation and overall deformation/ settlement occurs reduces with time. Consolidation of the tailings is of great importance for TSF operations, including questions related to the volume occupied by the tailings over time, and the amount of water that will require recycle or discharge over time. During the post-closure period, surface settlement of the closure cap will have an effect on surface grading and stormwater management, and the overall integrity of the closure cap.

Consolidation is typically assessed during the design process with laboratory tests including oedometer tests (ASTM D2435) and Constant Rate of Strain tests (ASTM D4186). These tests provide valuable information on the time dependent deformation characteristics of the tailings, albeit on small scale samples. It is therefore necessary to verify the time dependent deformation characteristics of the tailings with in-situ monitoring equipment. Typically, stand-pipe and vibrating wire piezometers are used to monitor pore-pressure changes (the force that moves the pore water).Various settlement measuring devices are also used, including settlement plates, settlement monuments installed at the surface, and settlement cells installed at various depths in the tailings. Consolidation can be accelerated by artificial measures, such as actively removing pore water (pumping) or using wick drains. Several other techniques, not necessarily common in TSF management, are also potentially available.



This figure will be replaced with a higher quality version in the next draft.

Data Source: Donlin Gold 2012

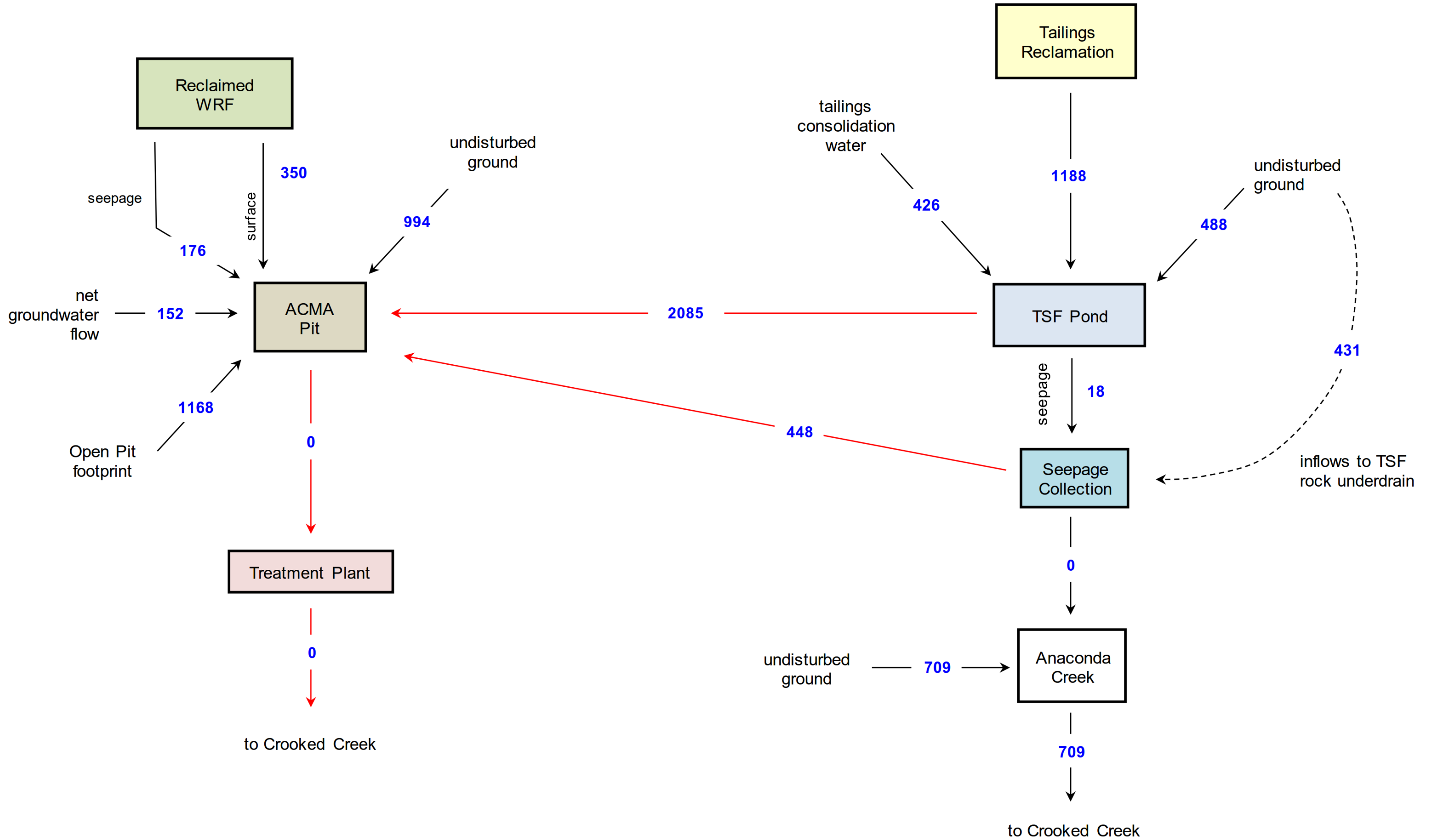
DONLIN GOLD PROJECT EIS

WATER MANAGEMENT PLAN DURING CLOSURE

NOVEMBER 2015

FIGURE 3.5-24

TSF impoundment volume pumped to ACMA Pit at end of Operations	8,190 acre-ft
Runoff accumulated in open pit backfill during Operations	8,910 acre-ft



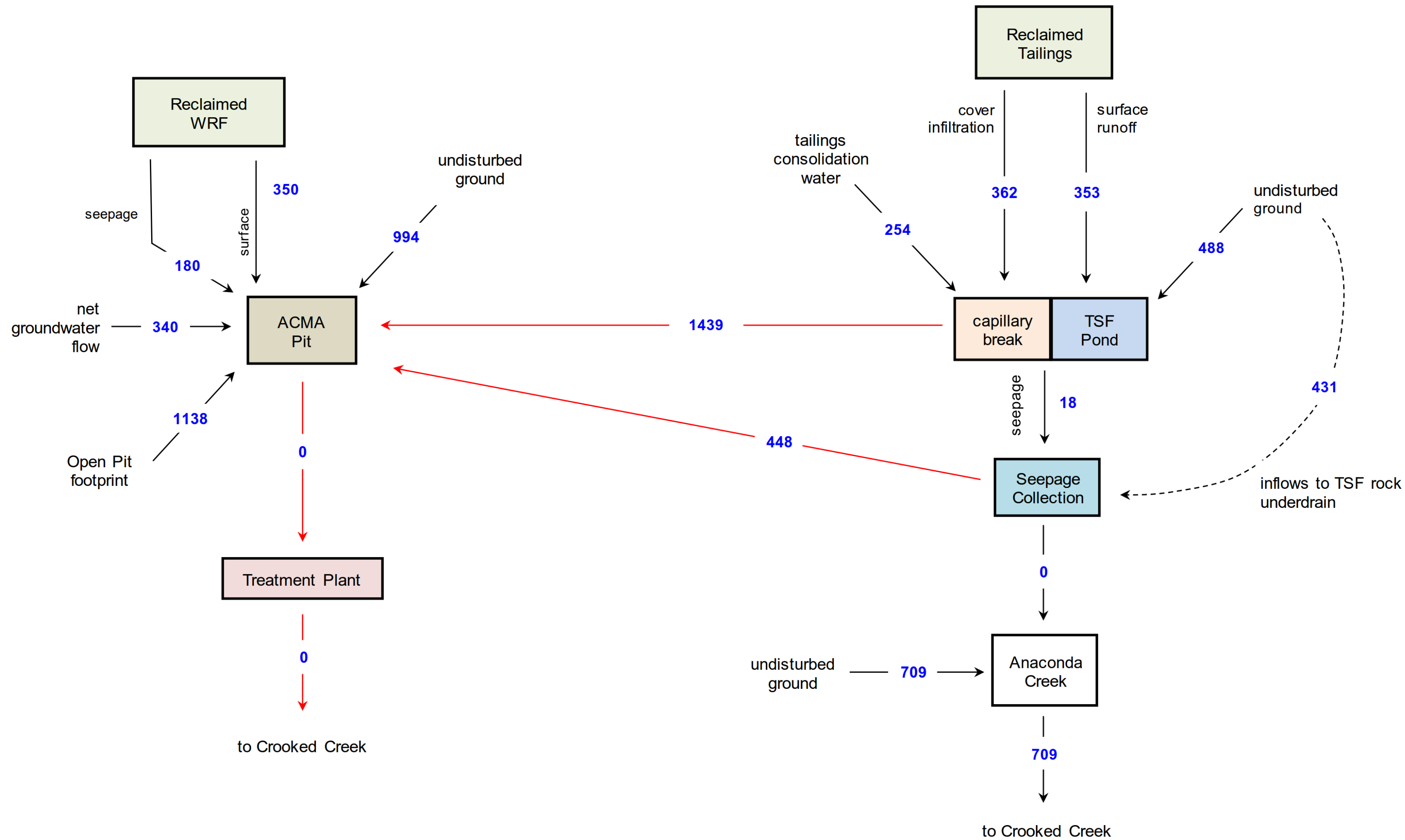
Note: Values (gpm) shown are averaged over Years 1 to 5 of closure. Red arrows denote pumping routes.

Data Source: BGC 2015f

DONLIN GOLD PROJECT EIS

SCHEMATIC WATER BALANCE DURING CLOSURE: YEAR 1 TO 5

NOVEMBER 2015 FIGURE 3.5-25



Note: Values (gpm) shown are averaged over Years 6 to 10 of closure (the TSF pond monitoring period). Red arrows denote pumping routes.

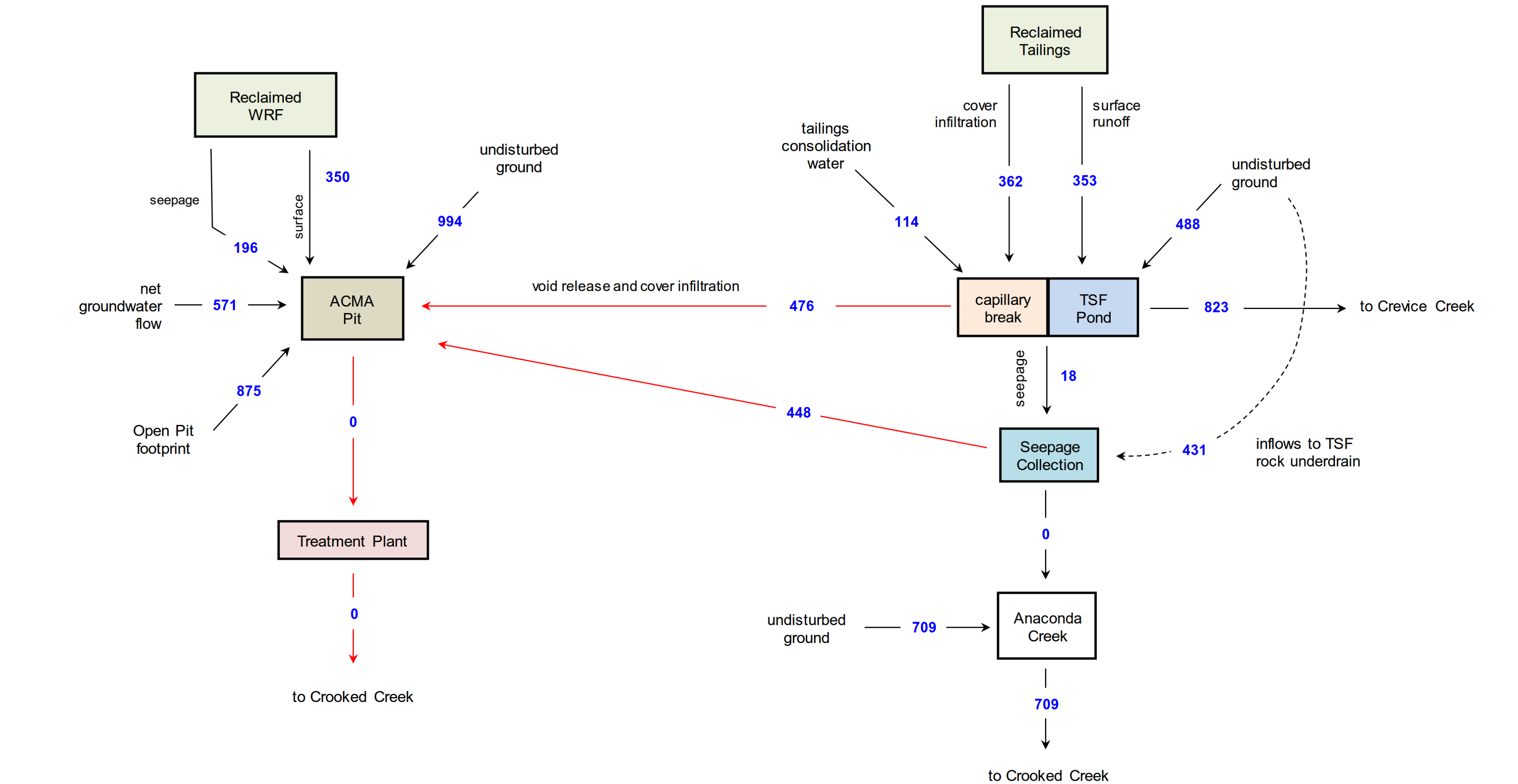
Data Source: BGC 2015f

DONLIN GOLD PROJECT EIS

SCHEMATIC WATER BALANCE DURING CLOSURE: YEAR 5 TO 10

NOVEMBER 2015

FIGURE 3.5-26



Note: Values (gpm) shown are averaged over Years 11 to 51 of closure (tailings consolidation water and TSF seepage water continue to be collected and pumped to ACMA Pit).
Red arrows denote pumping routes.

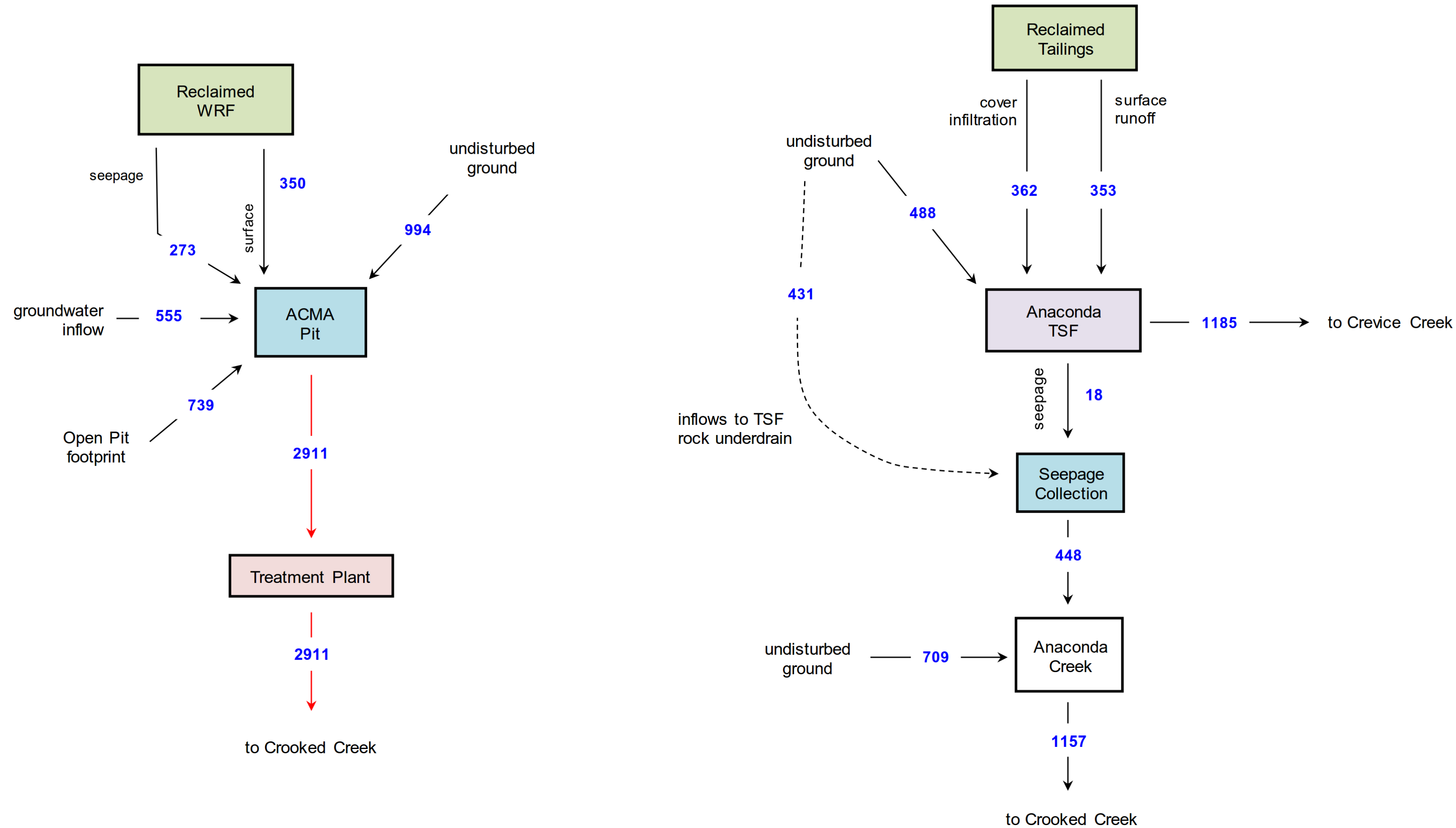
Data Source: bgc 2015f

DONLIN GOLD PROJECT EIS

SCHEMATIC WATER BALANCE DURING CLOSURE: YEAR 11 TO 51

NOVEMBER 2015

FIGURE 3.5-27



Note: Values (gpm) shown are averaged over Years 52 to 200 of closure. Red arrows denote pumping routes.

Data Source: BGC 2015f

DONLIN GOLD PROJECT EIS

SCHEMATIC WATER BALANCE DURING CLOSURE: YEAR 52 ON

NOVEMBER 2015

FIGURE 3.5-28

Runoff from the cover during this phase of closure would be collected in a lined pond that would be constructed in the southeast corner of the TSF facility (Figure 3.5-24). The pond would be sized to hold an average monthly runoff of 162 acre-feet (SRK 2012b). TSF cover runoff would be pumped to the pit lake until it can be demonstrated that runoff water quality is suitable for discharge to Crevice Creek through the TSF spillway, which is assumed to be after Year 10 of closure.

The spillway between the TSF pond and Crevice Creek would be designed to convey a PMF of 13,420 cfs (SRK 2012b). It is anticipated that stabilization of the Crevice Creek channel would be necessary downstream of the spillway in order to minimize potential impacts to the channel due to increased discharge. A detailed study on both fish habitat and channel stability in Crevice Creek would be conducted prior to construction of the spillway. The average annual discharge from the TSF pond to Crevice Creek, from closure Year 11 on, is shown on Figure 3.5-27.

Closure after Year 52. After Year 52 of closure, it is predicted that water infiltrating the TSF cover would no longer be mixing with tailings consolidation water and would be acceptable for discharge to Crevice Creek (Figure 3.5-28). This water would accumulate in the TSF pond after the temporary pond liner is removed (SRK 2012b). The prediction that water infiltrating the TSF cover would no longer be mixing with tailings consolidation water is based on tailings consolidation and void water removal (BGC 2011a; SRK 2012b). Excess tailings consolidation water, TSF runoff, and water infiltrating the cover material during reclamation would be captured in the TSF base rock layer (the capillary break between the tailings and cover). Once tailings consolidation is complete, there would be no more excess pore water (after Year 52), and surface contouring would direct cover runoff to the pond in the southeast corner of the TSF. TSF water would be pumped to the pit lake until suitable water quality conditions exist for discharge to Crevice Creek. Water quality monitoring is discussed in Chapter 5, Impact Avoidance, Minimization, and Mitigation.

Post closure, runoff contributions from Anaconda Creek to Crooked Creek will be reduced to the runoff generated by the approximately 1.8 square mile drainage area downstream from the TSF. Surface water from the TSF will exit through the emergency spillway to Crevice Creek and groundwater contributions from upslope of the reclaimed TSF (i.e. underdrain flows) will be captured in the SRS and pumped to the pit lake (BGC 2015h).

Effects on Crooked Creek

During the closure and post-closure phases, stream flow within the mine site would continue to be affected due to diversion and storage of surface water (BGC 2014i). While the pit lake is filling, stream flows in Crooked Creek will continue to be less than during the pre-mining condition, due to the pit continuing to intercept groundwater base flow and the redirection of water unsuitable for release from American and Anaconda creeks to the pit lake.

Once the pit lake is at the operating level, approximately Year 51 of mine closure (BGC 2015h), the pit lake water would be treated and discharged to Crooked Creek. Because the runoff coefficient of the reclaimed area is likely to be lower than the runoff coefficient of the undisturbed area prior to mining (BGC 2014i) and the AWT would only be operated during the summer months (i.e. about 6 months of the year), flows in Crooked Creek would continue to be somewhat lower than those prior to mining at some locations and in some months.

The predicted maximum average monthly reduction in stream flow, minimum average monthly reduction in stream flow, and average yearly reduction in stream flow at various Crooked Creek locations and at the mouth of American, Anaconda and Crevice creeks are presented in Table 3.5-28 (BGC 2015h). The estimates represent conditions after the pit lake has filled to its post-closure operations level, and are based on both the average stream flow conditions (i.e. 50 percent stream flow condition) and the 10th percentile stream flow condition. Results for the years during which the pit lake is filling to the operations level are not presented, as there is approximately a linear relationship between the flow in Crooked Creek at Year 20 of mining and the flow in Crooked Creek once the pit lake has filled to the operations level. The models indicate the following range of results in post-closure (BGC 2015h) (Table 3.5-28):

- Disturbed flows for American Creek and Crooked Creek below American Creek (both positive and negative changes compared to pre-mining conditions) are due to the larger watershed size of American Creek and pumping to the WTP in summer months. For the purposes of modeling, it was assumed that release of treated water from the pit lake WTP would be to the pit lake spillway channel (American Creek) during the six month WTP operation. In post-closure, this discharge would actually enter Crooked Creek directly via an outfall near Omega Gulch.
- During average flow conditions, it is estimated that the maximum monthly reduction in Crooked Creek stream flow would be about 13 percent, and the largest average yearly reduction would be about 7 percent, both of which would occur just below Anaconda Creek. For the 10th percentile low flow condition, it is estimated that the maximum monthly reduction of 17 percent would occur at American Creek and just below Anaconda Creek, and the largest average yearly flow reduction would be about 7 percent just below Anaconda Creek.
- Flow is predicted to be slightly higher in Crooked Creek along certain reaches and during certain months compared to pre-mining conditions, due to treated pit lake water discharged near Omega Gulch, and to increased runoff into Crevice Creek from the TSF spillway. For example, minimum monthly changes under average and low flow conditions are predicted to be flow increases ranging from 3 to 39 percent near the American and Anaconda Creek confluences, and increases ranging from 6 to 21 percent at Crevice Creek.
- At the two Crooked Creek sites downstream of all mine activity, Getmuna and Bell confluences located about 6 to 7 miles below Crevice Creek, post-mining flow changes would be negligible to minor compared to undisturbed conditions. Under average to low flow conditions, the maximum average monthly change, minimum average monthly change, and average yearly change in stream flow at these sites are estimated to range from -4 to -6 percent, +2 to +10 percent, and -1 to -2 percent, respectively.

Table 3.5-28: Summary of Percent Reduction in Streamflow After Pit Lake is at Capacity

	Average Flow Condition			10th Percentile Low Flow Condition		
	Max Month	Min Month	Avg. for Year	Max Month	Min Month	Avg. for Year
American Creek	-100	+96	-23	-100	+334	-23
Crooked Creek at American Creek	-11	+11	-3	-17	+39	-3
Anaconda Creek	-73	-64	-67	-75	-66	-70
Crooked Creek below Anaconda Creek	-13	+3	-7	-17	+22	-7
Crevice Creek	+2	+61	+43	+0	+64	+33
Crooked Creek at Crevice Creek	-12	+6	-4	-13	+21	-5
Crooked Creek at Getmuna Creek	-6	+3	-2	-6	+10	-2
Crooked Creek at Bell Creek	-4	+2	-1	-5	+8	-2

Notes:
1 This table is summarized from the data presented in BGC 2015h.
2 A minus sign (-) means there is a flow reduction due to mining. A plus sign (+) means the flow is higher after mining than prior to mining.
3 Positive flows in American Creek and Crooked Creek below American Creek are from the release of treated water from the pit lake WTP into the pit lake spillway channel (American Creek) during the six month WTP operation.

Summary of Mine Site Impacts

Under Alterative 2, overall direct and indirect impacts of the mine site activities on surface water flow are expected to range from minor to major during construction and operations (depending on stream reach, precipitation, and bedrock conditions) to minor after closure. Surface water diversion and storage in the American and Anaconda creeks, and interception of surface water and groundwater by the mine pit and pit dewatering wells in the American Creek watershed, would have impacts that range from low to high in magnitude, in that effects may or may not be within historic seasonal variation depending on season, watershed, and mine phase. The highest intensity surface water impacts (dewatering losses and tributary diversions) would be long-term in duration, occurring throughout operations and the early closure period. Water would infiltrate from Crooked Creek near the pit into the pit dewatering system, becoming a losing reach adjacent to the mine site, although most of the time the amount of infiltration would be a small proportion of the flow. During winter conditions, a majority of flow in Crooked Creek could infiltrate into groundwater and be diverted into the pit dewatering system.

The highest intensity surface water impacts would be long-term in duration, occurring throughout operations and the early closure period. However, effects on surface water near the mine pit would be permanent, because the pit lake level would be managed to remain below the level of water in Crooked Creek in order to induce groundwater flow from the creek to the lake at all times. This constitutes a permanent reversal of groundwater flow directions towards the pit lake, rather than towards local streams as occurs under pre-mining conditions, and an overall decrease in stream flow in Crooked Creek. After the pit lake achieves its maximum managed stage, the amount of leakage from Crooked Creek would be a small percentage of the overall flow in the creek, and the magnitude of the effects would be considered low. Surface water resources would be affected in a local area of approximately 20 square miles encompassing the proposed pit, WRF, and TSF. Effects in Crooked Creek could extend for several miles downstream of the mine, but would have negligible impact on the Kuskokwim River. As such, the geographic extent of surface water impacts would range from local to regional. While surface water is an abundant resource in the area, it is a shared resource and its use, diversion, and discharge are governed by state laws and regulations; thus, it is considered common to important in context.

3.5.3.2.2 TRANSPORTATION FACILITIES

Construction

Mine Access Road, Airstrip, and Camp

Mine Access Road. Under Alternative 2, a mine access road would be constructed between the mine site and Angyaruaq (Jungjuk) Port early in the mine construction phase (Figure 2.3-12 in Chapter 2, Alternatives). The road would be approximately 30 miles long and cross 50 streams and drainages requiring structures to convey surface water flow (Table 1, Appendix G). Five stream crossings would require bridges and the rest would require culverts (SRK 2013a). Additional construction along the mine access road would include a 3-mile spur road between the mine access road and the airstrip, the mine camp facilities, and mine access roads between facilities within the mine site. Road and pad construction material would be excavated from approximately 20 sites selected along the road corridor (Figure 2.3-12 in Chapter 2, Alternatives).

Construction of mine access roads and associated drainage structures would potentially impact existing drainage patterns and water quality. If located and constructed improperly, roads can block or restrict drainage during normal or flooding conditions. Road construction activities such as vegetation clearing, grading, and excavation work would expose areas to erosion, potentially increasing sediment concentrations in Crooked Creek tributaries crossed by the road. Permafrost has been identified at some locations along the route; however, it is not expected to have major impacts on drainage crossing development or road construction (SRK 2013a). Potential impacts from constructing roads in areas underlain with permafrost include increased thermokarst conditions (see Section 3.2, Soils).

Potential impacts from stream or drainage crossings would result if drainage structures are missing, undersized, or improperly constructed. The lack of a drainage structure can result in excessive pooling of water on the upstream side of the road and more frequent overtopping, which can lead to erosion of the road. Sediment eroded from roads may be deposited on the ground surface or within the stream channel at locations downstream from the road. Excessive sedimentation in a stream channel can destabilize the stream banks, causing the stream to widen and / or create a fish block.

Culverts would be installed using construction practices designed to prevent damage from heavy loads, pass the design discharge, and to prevent erosion at the outlets. Poor construction techniques, such as the use of frozen backfill at culverts, or inadequate compaction, can result in culvert collapse. If the toe of the road is too close to the inlet and outlet ends of a culvert, gravel from the road can eventually block or partially block the ends of the culvert. Culverts that require fish passage would be designed based on criteria used by ADOT&PF for design and construction for fish passage. Applicable stormwater control measures would be implemented to prevent erosion or offsite migration of sediment. Control measures implemented would include, but not be limited to, applicable erosion and sediment control measures that will be included in the Donlin Project SWPPP. Such measures might include material excavated on an as-needed basis to minimize surface disturbance and erosion; reclamation as soon as sites are no longer needed; recontouring to blend with topography or high walls left in stable condition; and revegetation. Individual measures would be designed, constructed, and maintained with regard to the site, other measures in use, and the construction methods used (SRK 2012c).

One two-lane bridge and four multiple steel arch structures would be constructed along the mine access road. Each structure would be constructed to prevent impacts to streams during normal and flood conditions. Increased runoff and erosion could result from construction activities including vegetation removal, soil excavation, and soil compaction. Soil around abutments would be retained using gabion rock baskets preventing soil erosion and increased sedimentation in the stream channel (SRK 2013a). To further minimize potential impacts to streams during construction, the length of time required to construct the structures would be minimized by pre-fabricating bridge structural components for installation on-site (SRK 2013a).

Airstrip. A gravel surfaced airstrip would be constructed approximately 9 miles west of the mine site, and would be accessed by a 3-mile spur road off the mine access road (Figures 2.3-12 and 2.3-13 in Chapter 2, Alternatives). The runway would be constructed on a ridge in the upper Montana Creek watershed, which is not a tributary to Crooked Creek. The runway would be 5,000 feet long and 150 feet wide, with appropriate vegetation clearing around the airstrip (SRK 2013a). The potential impact of airstrip construction on the surface water hydrology of the Montana Creek watershed would be a minor increase in runoff due to vegetation removal and soil compaction. Implementation of typical stormwater BMPs for the airstrip as part of SWPPP permitting, such as diversion ditches and wattles, is expected to attenuate these changes to runoff (Section 3.2.3.2.3, Soils, Erosion). Therefore, construction of the airstrip would likely have no measureable impact on stream flow in the Montana Creek watershed.

Permanent Camp. A permanent mine camp would be constructed along the Angyaruaq (Jungjuk) Road approximately 2.4 miles west of the mine site (Figure 2.3-12 in Chapter 2, Alternatives). Construction of the camp facility would be completed near the end of the road construction period, for use at the beginning of mine operation. The camp would be constructed on a ridge between small unnamed tributaries of Crooked Creek. The potential impact of construction of the permanent camp on the surface water hydrology of Crooked Creek would be a minor increase in runoff due to vegetation removal and soil compaction. Implementation of typical stormwater BMPs during camp construction as part of SWPPP permitting, such as diversion ditches and wattles, is expected to prevent substantial changes to runoff (Section 3.2.3.2.3, Soils, Erosion). Therefore, construction of the permanent camp is expected to have no measureable impacts to stream flow and water quality in Crooked Creek or its tributaries.

Summary. The mine access road, spur road, airstrip, permanent camp, and other auxiliary mine facilities would be constructed to maintain existing surface water flow systems, and the impact on magnitude and intensity of the flow is likely to be within the limits of historic seasonal variation. Thus, the magnitude of the direct and indirect impacts on water quantity is expected to be low. Because the roads and some of the pads will be in place beyond the life of the mine, the duration of the impact is expected to be long-term to permanent. Because the impacts are limited to discrete portions of the Project Area, the geographic extent of the impact is expected to be local. Because the impacts affect an abundant but shared and regulated resource, the context of the impact is considered common to important.

Ports

Angyaruaq (Jungjuk) Port. The Angyaruaq (Jungjuk) Port would be constructed on the north bank of the Kuskokwim River, near the confluence with Jungjuk Creek (Figure 2.3-12 in Chapter 2, Alternatives). The port would be constructed on an undeveloped 21-acre site, and would include barge cargo berths, port access roads, container storage areas, and fuel storage areas (SRK 2013a). The potential impact of Angyaruaq (Jungjuk) Port construction would be a minor increase in runoff due to vegetation removal and soil compaction, and possible increase in erosion.

A septic tank and leach field would be installed at the port, sized for a maximum crew of 20 people. The leach field would be placed in a location with suitable soils and topography to prevent failure and potential drainage onto the adjacent land surface or Kuskokwim River. The proposed location (Figure 2.3-11 in Chapter 2, Alternatives) would be confirmed in final design.

A flood-peak frequency analysis (BGC 2014e), a hydraulic model of the 100-year flood, and ice jam surveys (RECON 2014b) were used to design the fixed structure to be above the 100-year flood and known ice jam elevations. The flood frequency analysis was based on data collected at the USGS Kuskokwim River gauging station at Crooked Creek, located approximately 8.7 miles upstream from the proposed port.

The Angyaruaq (Jungjuk) Port design also includes a container storage area. The riverside edge of the container platform would consist of a sheet pile wall that extends an average of 150 feet into the Kuskokwim River (BGC 2014e). The sheet pile wall and fill are necessary to provide a level dock adjacent to the moored barges for the lift-trucks loading and unloading shipping containers. Potential impacts of installing a sheet pile wall on the Kuskokwim River include increased suspended sediment from channel bottom disturbance, as well as changes to flow velocities and direction upstream, downstream, and across the channel from the sheet pile wall. Changing the flow velocities and direction in a river can create both scour and deposition, which could lead to increased channel and bank erosion near the structure, as well as sediment deposition downstream from the structure.

Hydraulic analysis conducted at the proposed Angyaruaq (Jungjuk) Port location concluded that as designed, the sheet pile wall would not majorly impact Kuskokwim River channel morphology during average annual peak flow and 100-year flood conditions (BGC 2014e). However, the analysis did show that an eddy could form upstream from the structure during a 100-year flood event. If an eddy forms, scour could occur and induce bank erosion upstream of the sheet pile wall, therefore bank protection would be necessary (BGC 2014e). Monitoring and adaptive management recommendations that would reduce these effects are provided in Chapter 5 (Impact Avoidance, Minimization, and Mitigation).

During construction, the potential impacts of the Angyaruaq (Jungjuk) Port facility on surface water runoff and erosion, and Kuskokwim River flows, would be minimized by implementing BMPs for erosion control and construction at the port (Section 3.2, Soils). Surface water flow systems would be maintained and changes in water quantity and velocity would be within the limits of historical seasonal variation. Thus, the magnitude of the direct and indirect impacts on water quantity and velocity is expected to be low. Since the port will be used for the life of the mine and then removed, the duration of the impact is expected to be long-term. Impacts are expected to extend from the immediate project vicinity to hydraulically connected waters beyond the Project Area; therefore, the geographic extent of the impact would range from local to regional. Because the impacts affect an abundant but shared and regulated resource, the context of the impact is considered common to important.

Bethel Cargo Terminal and Fuel Terminal/Tank Farm. The location considered for the Bethel cargo and fuel terminal is shown on Figure 2.3-10 (Chapter 2, Alternatives). Potential impacts from the development of the new cargo terminal would include increased runoff and erosion due to vegetation removal and soil compactions. Erosion control BMPs developed for construction of these facilities would be used to minimize impacts to runoff and erosion (Section 3.2, Soils). Potential impacts to surface water hydrology from a fuel storage and transfer facility in Bethel would be minor due to Donlin Gold's use of an existing fuel storage facility (SRK 2013a). In the event new tanks would be constructed, impacts to surface water runoff and erosion would be prevented as the pad, liner, and containment structures are already in place.

Shoreline development at the Bethel Port would include construction of an open cell sheetpile bulkhead spanning about 850 feet along the shoreline to prevent erosion of the riverbank. This would result in creation of about 3 acres of new ground extending about 150 feet into the river from the current shoreline (Corps 2014a). The width of the bulkhead from the current shoreline is relatively small compared to the overall width of the river at this location (about 1,000 feet). The bulkhead would alter flow in the river as the current deflects around the structure, potentially resulting in increased erosion and deposition at either end. In addition, propeller wash from tugs at the new and existing facilities could result in increased bed scour in the immediate vicinity of the docks (discussed in the Barging section below). These impacts are expected to be of medium magnitude, in that they represent changes to the surface water flow system.

The potential impacts to surface water flow, runoff, and erosion during construction of the Bethel cargo and fuel terminals would be minimized by implementing and maintaining BMPs for erosion control and placement of rip-rap at either end of the new bulkhead. Thus, the magnitude of the direct and indirect impacts is expected to range from low to medium. Because the facilities would be needed throughout the life of the project and would likely be used after closure of the project, the duration of impacts is expected to be long-term to permanent. Potential impacts would be experienced in the immediate vicinity of the Bethel Port as well as hydraulically connected waters beyond the Project Area; therefore the geographical extent of impacts would range from local to regional. Because the potential impacts affect an abundant but shared and regulated resource, the context of the impact is considered common to important.

Dutch Harbor. Additional fuel storage capacity may be needed at Dutch Harbor to accommodate the Donlin Project. However, the existing infrastructure would reduce the amount of new construction required for the mine project. Potential impacts to surface water drainage from any new construction in Dutch Harbor would include increased runoff and sedimentation from removal of vegetation and soil compaction. Stormwater runoff and erosion control BMPs would be implemented and maintained during construction to prevent impacts to surface water (Section 3.2, Soils). Where possible, existing stormwater drainage infrastructure would be utilized, further reducing the construction impact.

The use of erosion control and construction BMPs would minimize the potential impacts to surface water hydrology from cargo and fuel storage construction activities in Dutch Harbor. Additionally, use of existing infrastructure when possible would limit the area disturbed during the construction period; thus, the magnitude of the direct and indirect impacts on surface water runoff is expected to be low. Because the facility would be needed throughout the life of the project and would continue to be used after completion of the project, the duration of the impact is expected to be long-term to permanent. Potential impacts would be experienced within the immediate vicinity of the port as well as hydraulically connected waters beyond the Project Area; therefore the geographic extent of the impact is considered local to regional. Because the potential impacts affect an abundant but shared and regulated resource, the context of the impact is considered common to important.

Barging

Operational Guidelines

The section of the Kuskokwim River from Bethel to Crooked Creek currently handles medium size tows (40 by 160 feet with a draft of 6-8 feet), and approximately 68 freight and fuel barge tows per year serve the villages upriver of Bethel. The typical barge tow is one barge pushed by one tug; however, Crowley Marine operates two and four fuel barge tows in a side by side configuration when river water levels allow. Further detail on existing Kuskokwim River transportation is discussed in Section 3.23, Transportation.

Under Alternative 2, general cargo and fuel would be transported up the Kuskokwim River to Bethel on ocean barges (Section 2.3.2.2). From Bethel, both cargo and fuel would be transported upriver approximately 168 river miles to Angyaruaq (Jungjuk) Port by river barge during ice free conditions. During the construction period, the Bethel cargo terminal would receive a total of 16 cargo deliveries from the ocean barge fleet. The river barge draft and tow configuration would depend on the average daily discharge and corresponding water levels and widths along the Kuskokwim River. There are a total of eight critical sections along the river extending for 199 river miles between Bethel and Angyaruaq (Jungjuk) (including those at both ports) (Figure 3.5-29). Data collected at the USGS Kuskokwim River gauging station at Crooked Creek would be used to monitor water levels and discharge during the barge season to guide river travel through these sections. River barge tow capacity guidelines, developed using long-term hydrologic data from the USGS gauging station, bathymetric survey data collected at the critical sections, and Corps guidelines for shallow-draft waterways (Corps 1980), would be used during the project and are presented in Table 3.5-29.

Table 3.5-29: Kuskokwim River Barge Guidelines

Kuskokwim River Average Daily Discharge[1]	River Barge Guideline
≥ 73,000 cfs	Cargo and fuel requirements could be delivered within a 60-day period under average flow conditions.
< 39,000 cfs	The Kuskokwim River would be considered not navigable between Nelson Island and Angyaruaq (Jungjuk) Port.
Between 39,000 cfs and 41,500 cfs	At Nelson Island, the tow would be relayed using a 1 x 1 tow configuration through these narrows.

Table 3.5-29: Kuskokwim River Barge Guidelines

Kuskokwim River Average Daily Discharge[1]	River Barge Guideline
> 41,500 cfs	A 2 x 2 tow does not need to relay at Nelson Island.
Between 39,000 cfs and 44,000 cfs	At upper Oskawalik, the tow would be relayed through with a 1 x 1 tow configuration through these narrows.

Notes:
1 Average daily discharge and stage would be obtained from the USGS Kuskokwim River Gauging Station near Crooked Creek.
Source: AMEC 2014.

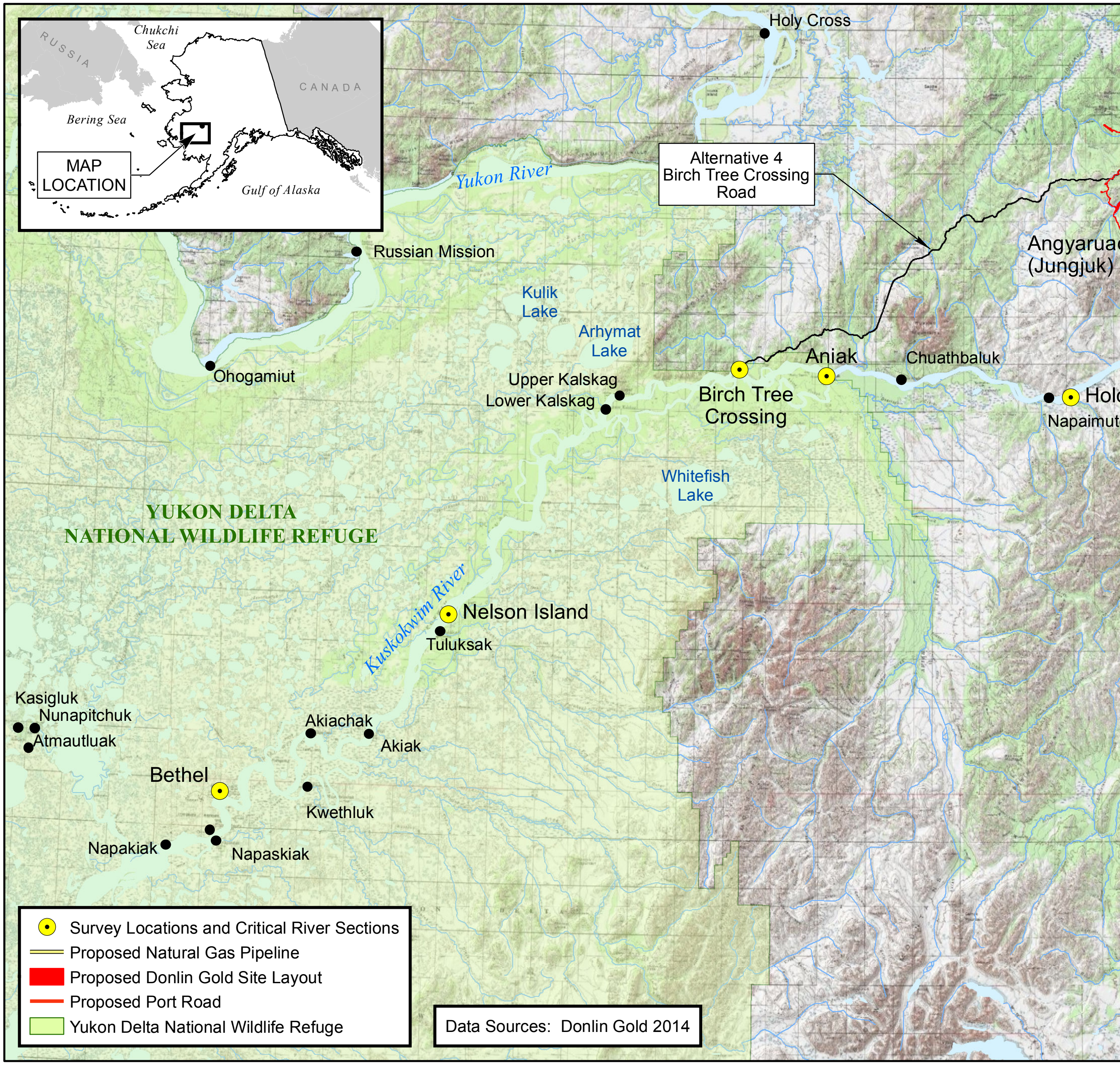
Wave-Induced Bank Erosion

Potential impacts from barge transportation of fuel and cargo on the Kuskokwim River include barge-induced bank erosion, disturbance of channel bottom sediment from tug propellers, and barge stranding. As described in Section 3.5.2.2.3, a large amount of bank erosion occurs on the Kuskokwim River due to natural processes. Although barge-induced bank erosion could increase bank erosion above natural erosion rates, a study of the wave height and energy generated from barge traffic (BGC 2007c, 2015m) indicates that the increase due to project barge traffic is likely to be small. Potential maximum wave heights from barge traffic were calculated using both the PIANC (1987) and Sorenson and Weggel (1984) equations (BGC 2015m). Wave heights during upstream travel were calculated to be between 0.05 and 0.22 feet (Table 3.5-30), and downstream travel wave heights were calculated to be between 0.34 and 0.74 feet (Table 3.5-31) due to increased barge speed. As a percentage of river tractive energy, barge-generated wave energy would vary between 3 and 12 percent. Furthermore, the primary cause of bank erosion along the lower Kuskokwim River is related to removal of loose material at the base of the bank, making the bank more susceptible to mechanical erosion and thermoerosional niching associated with high water levels. Therefore, based on this evaluation, it was concluded that barge-induced waves would not majorly impact Kuskokwim River bank erosion rates. The potential for bank erosion from propeller wash and scour is discussed in the following section.

Table 3.5-30: Maximum Wave Heights for Upriver Loaded Trip

Reach	Barge	Absolute Vessel Speed (feet per second)	PIANC (1987) (feet)	Sorensen & Weggel (1986) (feet)
Aniak	Fuel	8.7	0.15	0.05
	Cargo	9.6	0.22	0.06
Kalsag	Fuel	8.8	0.15	0.05
	Cargo	9.7	0.21	0.10
Tuluksak	Fuel	8.9	0.11	0.05
	Cargo	9.8	0.17	0.10
Akiak	Fuel	9.2	0.14	0.06
	Cargo	10.1	0.21	0.11
Akiachak	Fuel	9.1	0.15	0.05
	Cargo	10.0	0.22	0.11

Source: BGC 2015m



DONLIN GOLD PROJECT EIS

SURVEY LOCATIONS AND CRITICAL SECTIONS OF THE KUSKOKWIM RIVER

NOVEMBER 2015

FIGURE 3.5-29

Table 3.5-31: Maximum Wave Heights for Empty Return Voyage

Reach	Barge	Absolute Vessel Speed (feet per second)	PIANC (1987) (feet)	Sorensen & Weggel (1986) (feet)
Aniak	Fuel	14.1	0.52	0.69
	Cargo	14.1	0.52	0.74
Kalsag	Fuel	14.0	0.47	0.56
	Cargo	14.0	0.47	0.58
Tuluksak	Fuel	13.9	0.34	0.38
	Cargo	13.9	0.34	0.39
Akiak	Fuel	13.6	0.35	0.41
	Cargo	13.6	0.35	0.40
Akiachak	Fuel	13.7	0.38	0.47
	Cargo	13.7	0.38	0.46

Source: BGC 2015m

Propeller Wash and Scour

A tug's propeller produces a jet of water moving away from the back or stern of the tug. After about three propeller diameters the jet begins to diffuse through the water column. The diffusion of the jet can eventually reach the bottom of the river, and if the velocity in the jet is large enough, will cause erosion (i.e. scour) of the riverbed, resulting in increased suspended sediment concentrations and turbidity. The magnitude of the impact is a function of the horsepower associated with the propeller, the diameter of the propeller, the water depth below the propeller, whether the tug is stationary or moving, and the size of the riverbed material. If there is more than one propeller on the tug, the distance between the propellers also affects the magnitude of the impact. Because it takes time for erosion of the bed to occur even when the velocities are high enough to cause erosion, the impact of the jet produced from a moving tug can be dramatically less than that of a stationary tug. Thus, the impact of a tug's propeller on riverbed erosion, suspended sediment, and turbidity is likely to be greatest at ports or relay points, when the tug is maneuvering for barge launch or landing.

Velocity and Shear Stress. An analysis of the potential water velocity and shear stress acting on riverbed material that would be caused by propeller jets was conducted by URS (2014a) based on tugs with four propellers, a power per propeller of 150 to 600 horsepower (hp) proposed by Fernandez (2014d), and an evaluation of water depths below the keel ranging from 2 to 50 feet. Estimates of velocity and shear stress were calculated using an approach by Maynord (2000) who developed experimental data for commercial tows in moving water. Because the Maynord study was based on a single set of experiments, the results were also compared to a "classical" approach (from The Rock Manual, 2007) based on a stationary tug with no rudder, and no ambient current present. The results of the two methods were found to be roughly comparable for under-keel water depths less than about 6 feet, and diverge in deeper water due to the effect of the moving tug and current, and to different friction coefficient approaches in the methods. Friction coefficients were adjusted in the Maynord model using conservative assumptions for grain size and bottom shape to more closely match realistic field conditions (compared to laboratory particle size experiments) and to provide shear stress results that represent a reasonable upper bound of effects expected (Table 3.5-32). Thus, the results using the Maynord (2000) approach, shown in Table 3.5-32, are considered a reasonable estimation of the maximum velocity and shear stress that would act on the Kuskokwim riverbed during upstream barge travel through relatively shallow water.

Table 3.5-32: Maximum Estimated Velocity and Shear Stress on Kuskokwim Riverbed from Propeller Wash

Power per Propeller[1] (hp)	Throttle Setting (% of maximum)	Depth of Water below Keel (ft)						
		2	4	6	8	10	15	20
Water Velocity at Riverbed[2] (ft/s)								
600	100	11.91	6.39	3.49	1.63	0.29	0.00	0.00[3]
450	75	10.59	5.53	2.84	1.11	0.00	0.00	0.00
300	50	8.94	4.44	2.04	0.47	0.00	0.00	0.00
150	25	6.58	2.89	0.88	0.00	0.00	0.00	0.00
Shear Stress on Bed Material[2,4] (N/m^2)								
600	100	565	106	23	4.1	0.11	0.00	0.003
450	75	447	79	15	1.9	0.00	0.00	0.00
300	50	318	51	8.1	0.34	0.00	0.00	0.00
150	25	172	21	1.5	0.00	0.00	0.00	0.00

Notes:

1 From Fernandez (2014d).
2 Based on Maynord (2000). Assumes tug with rudder and 4 propellers, moving upstream at 10 ft/s (7 mph), against flowing water of 6 ft/s.
3 All results from 20 to 50 ft = 0.00 ft/s or N/m2.
4 Assumes bed particle size of 3.5 mm (very fine gravel) to convert from smooth to rough boundary; smaller particles would result in smaller shear stresses.

hp = horsepower
ft/s = feet per second
N/m^2 = Newtons per square meters
mph = miles per hour

Source: URS 2014a.

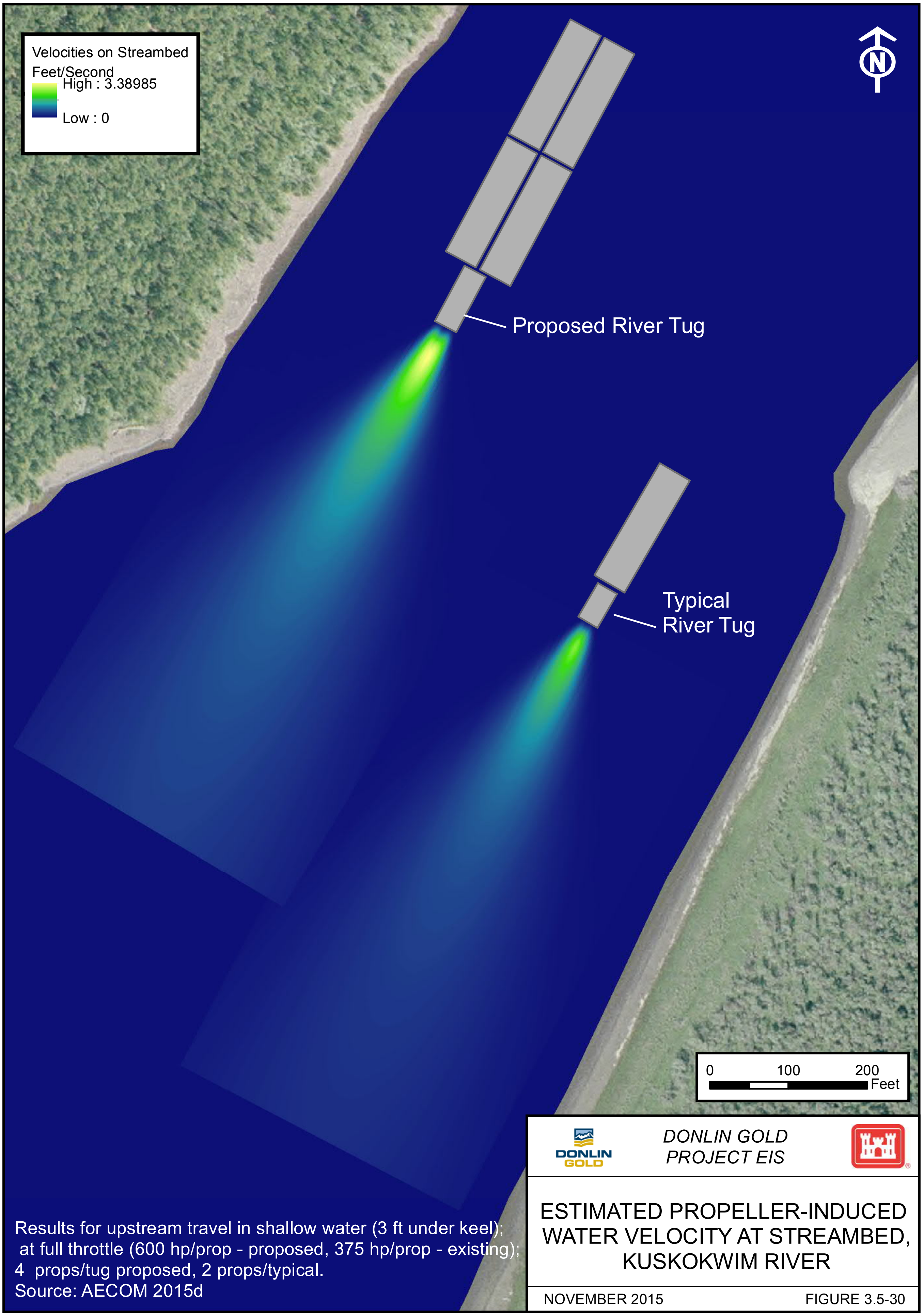
The results in Table 3.5-32 indicate water velocities at the river bottom ranging from 3.5 to 12 feet/second for a tug operating at maximum power through water with under-keel depths of 2 to 6 feet. Results for more typical throttle settings of 450 hp (75 percent of maximum) for upstream travel (Fernandez 2014d) were slightly less, in the range of 3 to 11 feet/second in shallow water depths. (By comparison, the velocity of the Kuskokwim River is about 6 feet/second.) For typical tugs currently operating on the river (twin or triple screw, 375 to 400 hp per propeller (Fernandez 2014d), maximum riverbed velocities would be about 1 to 2 feet/second less than that of the proposed tugs in shallow water depths.

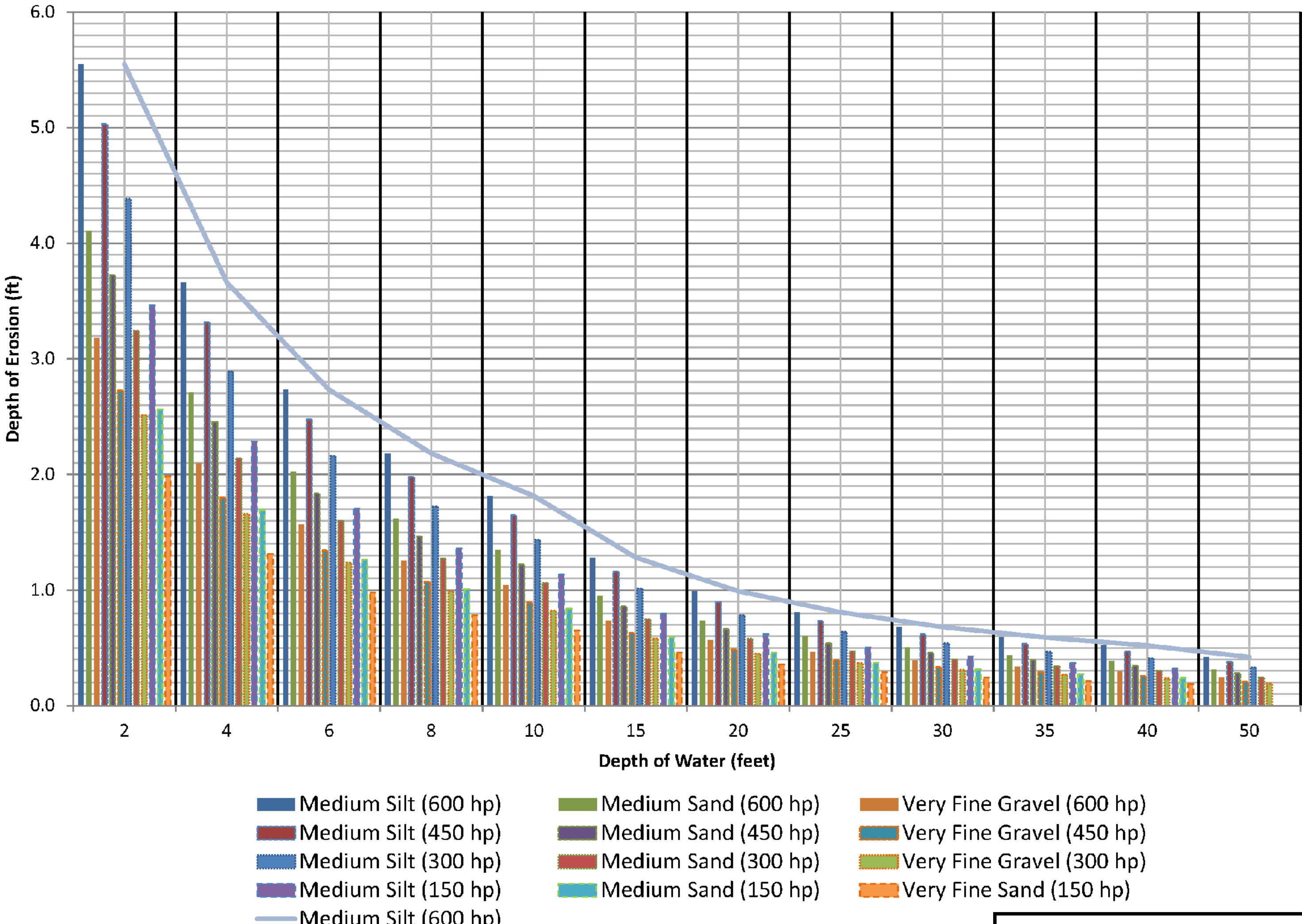
Calculations of jet velocity attenuation with distance from the propellers were conducted based on the classical approach (the Rock Manual 2007) to provide a conservative estimate of the lateral extent of the propeller flow field. Figure 3.5-30 provides an example of these results at maximum power and 3 feet of under-keel clearance for both proposed and existing tugs. Based on this shallow water example, the propeller flow field for the proposed barge tows would extend several hundred feet behind the stern and would be slightly wider than the width of the 4x4 barge tow. The flow field for a typical tug currently operating on the river is about two-thirds of the size of the proposed tugs. The effects of these results on fish and fish habitat are further discussed in Section 3.13 (Fish and Aquatic Resources).

Bed Erosion. The depth of bed erosion expected from the propeller jet stream was estimated by comparing the maximum shear stress (Table 3.5-32) to the critical shear stress required to mobilize particles of different size (Julien 1998). Based on these comparisons, velocities of the magnitude depicted on Figure 3.5-31 would be sufficient to erode cobbles and coarse gravel, which is coarser than the average material in the Kuskokwim riverbed in this region. Most Kuskokwim River sediment between Bethel and Jungjuk ranges from coarse silt to fine sand with occasional gravel (RWJ 2008a, 2010a).

The effect of water depth on bed scour at various throttle settings and grain sizes was further evaluated by URS (2014a) using a relationship developed by Hong et al. (2012), which is dependent on the amount of time that shear stress acts on the bed material. This approach was used to estimate the maximum depth of erosion over a short period as a measure of the impact of erosion during barge travel. Results are depicted on for a stationary tug after 1 minute as a conservative estimate of the effects of a slow moving barge, using a range of grain sizes most commonly found in Kuskokwim River sediment (additional analysis is provided in Section 3.13, Aquatic Resources, based on localized gravel fish habitat). The results in show a clear decrease in the depth of erosion with water depth. For example, for a typical throttle setting of 75 percent of maximum power (450 hp / propeller) for the proposed tugs, the depth of erosion for silty sand bed material in shallow water with 3 feet of under-keel clearance (total water depth of 6 feet) would be about 3.5 feet after 1 minute for each propeller. Because the propeller centerlines would be spaced about 10 feet apart (Fernandez 2014d), each propeller would likely create its own scour trough, which could overlap with each other in shallow water. As a comparison to baseline conditions, for a typical twin or triple screw tug currently operating on the river at 75 percent of maximum power (about 300 hp / propeller), the depth of erosion in shallow water (3-foot under-keel clearance) would be about 3 feet per propeller, or about ½-foot less than the tug size proposed by Donlin Gold.

For a more moderate water depth having 7 feet of under-keel clearance (total water depth of 10 feet), the depth of erosion for both the proposed action and baseline cases would be about 1.5 to 2 feet. The results for both cases are expected to be less for a moving tug, which is unlikely to erode even fine bed material in water more than 10 feet deep. Therefore, in moderate to deep water or areas where the power to the propellers is low, the magnitude of the impact is expected to be low. There could be some disturbance of the sediment on the riverbed and some increased turbidity, but the changes are expected to be minor and temporary.


Velocities on Streambed
Feet/Second
High : 3.38985
Low : 0
Proposed River Tug
Typical
River Tug
0
100
200
Feet
Results for upstream travel in shallow water (3 ft under keel);
at full throttle (600 hp/prop - proposed, 375 hp/prop - existing);
4 props/tug proposed, 2 props/typical.
Source: AECOM 2015d
DONLIN GOLD
DONLIN GOLD
PROJECT EIS
ESTIMATED PROPELLER-INDUCED
WATER VELOCITY AT STREAMBED,
KUSKOKWIM RIVER
NOVEMBER 2015
FIGURE 3.5-30



Notes:
1. Results based on relationship by Hong et al. (2012) for a stationary tow after 1 minute. A moving tow would scour less than shown; e.g., a tow moving at 5 mph would move about 400 feet in 1 minute, so would likely scour less at any specific location within the 400-foot length.
2. 450 hp represents typical upriver tow with full barge load, or 75% of maximum throttle (Donlin Gold 2014).
3. Most Kuskokwim River sediment ranges from course silt to fine sand, with occasional gravel (RWJ 2008, 2010).
4. Depth shown is under-keel water depth.

Data Source: AECOM 2015b

DONLIN GOLD PROJECT EIS

ESTIMATED DEPTH OF EROSION FOR VARIOUS GRAIN SIZES AND WATER DEPTHS, KUSKOKWIM RIVER

NOVEMBER 2015

FIGURE 3.5-31

In shallow water or areas where high power to the propellers is needed (e.g., maneuvering around a bend, or staging tows in shallow areas), the magnitude of the impact is expected to be medium, in that scour from the proposed tugs would be measurable above baseline conditions and could represent a potential change to the local flow system. The proposed project would add roughly twice as many barge trips (about 122 per year) to the current barge traffic (about 68 per year), and would erode 1 to 2 more parallel troughs in shallow water with the proposed 4-propeller configuration than existing tugs on the river would, with scour depths estimated to be about one-half foot deeper than those from existing tugs. With time and distance from the proposed tugs, as well as distance from the shallow critical areas, turbidity would decrease to background levels due to settling and dispersion, and the depth of erosion would decrease to near baseline levels. It is possible that the river bottom could take on a "plowed" appearance in shallow areas after the passage of several tows; since they would probably not follow exactly the same path, the holes and dunes that are formed would be intermixed. The area would be expected to return to normal every spring, or after a period of high river flow.

A higher level of impact could also occur near piers or docks where the barges are being maneuvered into place and the tugs get close to the shore. The scour results on also apply to stationary or locally maneuvering vessels at ports after 1 minute in one location, or tugs holding position on the river for 1 minute while waiting for passage of other traffic or tying up at a relay point. Tugs maneuvering at ports tend to use short bursts of medium power levels, which could create less scour than that described above for a tug underway upriver, but possibly more scour could occur if longer periods of maneuvering are required. Likewise tugs holding station on the river against the current would use less power than that needed for upriver travel, but could hold position longer than one minute.

When the tugs are close to shore, it is possible that the propeller jet could cause erosion/scour of the river banks, an effect that is not likely to return to normal after spring breakup or high flows. Because propeller-induced velocities would be mostly directed parallel to shore when a tug is underway (Figure 3.5-30), this effect is only expected to occur when tugs are very close to the banks, or when turning near or maneuvering in or out of docks when jets could be pointed towards the banks. When a tow is underway, the effect would be limited by the size of the tow requiring a minimum distance from the bank to be maintained to avoid grounding. Bank erosion effects are expected to be minor at the Bethel dock because shore protection is planned as part of the design. Monitoring and adaptive management is recommended in Chapter 5, Impact Avoidance, Minimization, and Mitigation, to consider the addition of shoreline protection at the Angyaruaq (Jungjuk) dock if warranted to mitigate bank erosion effects from turning vessels.

Although barging may continue beyond the life of the mine, the impact related to riverbed erosion is expected to be erased after each high flow. Similarly bank erosion caused by a tug would be expected to be erased by the river with time, i.e., as the natural rate of bank erosion catches up to the portion of the bank eroded by the tug, but may take much longer than a year. Therefore, the duration of the impacts are expected to be temporary to long-term. Because the impacts would affect discrete shallow (critical) sections and ports along the Kuskokwim River (Figure 3.5-29), which are hydraulically connected between each other and beyond the Project Area, the geographic extent of the impact would range from local to regional. Since the impacts affect an abundant but shared and regulated resource (i.e. the Kuskokwim River), the context is considered common to important.

Barge Stranding

Known barge stranding incidents that occurred on the Kuskokwim River between 2002 and 2013 are summarized in Table 3.23-2 (Transportation). These barge grounding incidents were from tank and freight barges, towing vessels, and freight ships. One barge stranding was reported near Aniak, and the remaining groundings occurred downstream from Bethel. However, barge stranding related to the proposed barge plan is considered to be an unlikely event due to use of barge operating guidelines (Table 3.5-29) and other planned mitigation (AMEC 2014; SRK 2013a). In the event of a stranding, potential impacts could include disturbance of the channel bottom from the barge pushing on the channel bottom, propeller wash from the tug, possible increased bank erosion from propeller wash depending on distance from shore, and deflected stream flow around the stranded barge. Based on the barge guidelines listed in Table 3.5-29, barge stranding potential would be greatly reduced due to the cut-off flow of 39,000 cfs that would prevent barge transportation above Nelson Island during low water conditions. Additionally, the barge configuration would be altered if relays are necessary at Nelson Island and upper Oskawalik, reducing the potential for barge stranding. In the event of a barge stranding, Donlin Gold would have a number of methods available to free the barges, depending on the circumstance (Donlin Gold 2013e).

The potential impacts of barge transportation and likelihood of stranding would be minimized by implementing the barge operating guidelines (Table 3.5-29). Donlin Gold's barge plan includes periodic surveying of the active channel to monitor any changes to the channel at critical locations, and a barge loading system designed to anticipate upstream water depth such that barges are loaded to maintain an appropriate draft. Donlin Gold would also utilize BMPs with respect to navigation aids and operating procedures. Therefore, the magnitude of the direct and indirect impacts of barge stranding on the Kuskokwim River during mine construction and operations is expected to be low. Because some barging would continue beyond the life of the mine for closure and monitoring activities, the duration of the potential impact is expected to be long-term to permanent. Because potential stranding impacts would affect discrete areas that are also hydraulically connected to waters beyond the Project Area, the geographic extent of the impact would be considered local to regional, and because the impacts affect an abundant but shared and regulated resource, the context is considered common to important.

Operations and Maintenance

Mine Access Road, Airstrip, and Camp

Potential impacts of the mine access road, airstrip and airstrip access spur road, and the mine camp facility on surface water hydrology during mine operations include increased stormwater runoff from road and pad surfaces, and increased erosion and sedimentation due to improperly designed and maintained road ditches and stream crossings during flood events. As discussed in the road construction section above, the road, pads for the airstrip and mine camp, and stream crossings will be designed to minimize potential impacts on surface water hydrology, water quality, and fish passage. Road and pad maintenance BMPs, including application of dust suppressants during dry periods, routine grading, and routine maintenance of drainage ditches and stream crossings, would be implemented and maintained during the mine operation period.

As vegetation becomes reestablished after construction activities end, potential erosion and sedimentation from disturbed areas would reduce greatly. The road surface would potentially yield additional runoff compared to native terrain. Since the roads would generally run perpendicular to the drainages crossed, the limited disturbance of the road would minimally increase the quantity of runoff to any single receiving tributary; thus, the magnitude of the direct and indirect impacts is expected to be low. The duration of impacts is expected to be long-term to permanent, as roads and some of the pads will remain in place beyond the life of the mine. Because the impacts are limited to discrete portions of the Project Area, the geographic extent of the impact is considered local. Surface water is an abundant but shared and regulated resource; therefore the context of the impact is considered common to important.

Ports

Angyaruaq (Jungjuk) Port. The potential impacts of the Angyaruaq (Jungjuk) Port during operations include increased stormwater runoff due to facility pads, roads, and the cargo storage area. Stormwater drainage infrastructure such as ditches and culverts would be maintained during operations so that they convey flow as designed. Areas disturbed during construction that are not in high traffic locations would revegetate, which would help reduce surface water runoff from the port area. The port septic tank and leach field would be monitored to ensure proper operation. The septic tank would be pumped on a regular basis and trucked to a sewage treatment facility at the mine site.

The Angyaruaq (Jungjuk) Port would be operational only during the ice-free shipping season. Therefore, operations would not be directly affected by ice jam events. The river bank upstream from the sheet pile wall would be monitored for increased erosion due to the potential formation of an eddy during above average flows or flood events. River bank protection would be installed to prevent impacts from bank erosion at this location. The potential for sediment deposition at the fuel barge berth could result from reduced stream flow velocities at the opening. Periodic dredging of deposited sediment at the berth opening may be necessary during the operation period for fuel barge access. Potential impacts from dredging would include increased suspended sediment and turbidity; however, all dredging activities would be administered through a Corps permit that would require implementation of dredging BMPs to minimize impacts.

The potential impacts to surface water hydrology from the Angyaruaq (Jungjuk) Port during operations would be minor due to maintenance of stormwater drainage infrastructure, revegetation of areas disturbed during construction, and monitoring and maintenance of the sheet pile wall. Thus, the magnitude of the direct and indirect impacts is considered low. Since the port will exist during the life of the mine but then be removed (with the exception of the barge landing), the duration of the impact of the port is expected to be long-term. Because the impact affects the immediate vicinity of the port as well as hydraulically connected waters beyond the Project Area, the extent of the impact is considered local to regional. The context of impacts is considered common to important, as surface water is an abundant but shared and regulated resource.

Bethel Cargo Terminal and Fuel Terminal/Tank Farm. Potential impacts of the cargo and fuel terminal use in Bethel during the operations and maintenance phase include increased stormwater runoff and sedimentation from the new barge cargo facilities added during the construction phase, and continued deflection of river flow around the new bulkhead with potential related erosion and sedimentation.

The potential impacts to surface water hydrology from the Bethel cargo and fuel terminals during the operations and maintenance phase would be minor overall due to the use of existing fuel and cargo storage facilities, implementation of stormwater runoff and erosion control BMPs, and placement of rip-rap at either end of the bulkhead. Therefore, the magnitude of direct and indirect impacts to water quantity and erosion are expected to be low to medium, in that the bulkhead would continue to alter surface water flow during operations. The use of the Bethel facility would likely continue beyond completion of the project, making the duration of the impact long-term to permanent. Because the potential impacts would primarily affect the immediate vicinity of the port, but extend to hydraulically connected water beyond the Project Area, the geographical extent of the impact is considered local to regional. The context of impacts is considered common to important, as surface water is an abundant but shared and regulated resource.

Dutch Harbor. Cargo storage and fuel storage terminals in Dutch Harbor would be operated by third-party terminal operators. The potential impacts to surface water hydrology from cargo and fuel storage during mine operation in Dutch Harbor would be minor due to existing stormwater infrastructure and erosion control BMPs. The magnitude of the direct and indirect impacts of operation within existing cargo and fuel storage areas on surface water quantity and erosion are expected to be low. The use of the Dutch Harbor facility would continue beyond project completion; therefore the duration of the impact is expected to be long-term to permanent. Because the potential impacts would primarily affect the immediate vicinity of the port, but extend to hydraulically connected waters beyond the Project Area, the geographic extent is considered local to regional. The context of impacts is considered common to important, as surface water is an abundant but shared and regulated resource.

Barging

Cargo and fuel would be barged to Angyaruaq (Jungjuk) Port during each year of mine operation. Twelve marine cargo barges and 14 marine fuel barges would deliver to the Bethel Port during the open water season of each year. River barges would then transport the cargo and fuel from Bethel to the Angyaruaq (Jungjuk) Port. The river barge plan is based on a 110-day open-water shipping season (AMEC 2014), and could be accomplished in 60 days of average flow conditions. Accounting for low flow conditions that could occur during the shipping season, it is estimated that there would be 64 round trip barge tows for cargo and 58 round trip barge tows for fuel transport between Bethel and Angyaruaq (Jungjuk) Port each season, which would add roughly two times more barge traffic to the river than currently exists (Section 3.23, Transportation). No dredging is predicted to be required for barge operations. Based on a review of 60 years of Kuskokwim River discharge records collected at the USGS Crooked Creek gauge (URS 2014c), there is likely to be greater than 110 available barging days in more than 90 percent of years. These data are described in more detail in Section 3.26, Climate Change.

Potential impacts of barge operations on the Kuskokwim River would be the same as those discussed under Construction above, and include wave-induced bank erosion from barges, disturbance of channel bottom sediment from tug propellers compared to baseline conditions, and barge stranding due to low flow conditions. Barge operation guidelines were developed to minimize impacts from barge traffic on the Kuskokwim River (Table 3.5-29). Additionally, a loading system has been designed to anticipate upstream water depths so that barges are loaded accordingly and barging would not occur at flows below 39,000 cfs. Discharge and stage would be monitored daily at the USGS Kuskokwim River gauging station at Crooked Creek for use as a guide for estimating water depths downstream, and the active channel would be surveyed periodically to monitor changes at critical locations, such as Nelson Island and upper Oskawalik. Based on these measures and other operational and design measures planned by Donlin Gold (see AMEC 2013), barge stranding potential would be greatly reduced. Therefore, the magnitude of most barge impacts on the Kuskokwim River during operations is expected to be low, although propeller scour in shallow areas could result in medium magnitude effects (local flow alterations at the riverbed above baseline effects from existing tugs). Because barging would continue throughout the life of the mine, and may extend beyond the life of the project, the duration of the impact is expected to be long-term to permanent. Impacts would be experienced at both discrete shallow points in the river, as well as hydraulically connected waters beyond the Project Area; therefore the geographic extent of the impact is expected to be local to regional. The context of impacts is considered common to important, as surface water is an abundant but shared and regulated resource.

Surface Water Use

Potential impacts from barge transportation on surface water use along the Kuskokwim River could result from increased sediment in the channel due to barge-induced bank erosion and disturbance of the channel bottom by tug propellers (prop wash). Barge transportation guidelines are designed to minimize potential impacts to the river, and, as discussed in Section 3.5.2.2.3, there are currently no in-stream flow reservations along the river and a limited number of surface water rights near Bethel and Aniak. Additionally, the Kuskokwim River transports high volumes of sediment annually, and any increase in sediment in the channel resulting from barge transportation would likely be negligible. Therefore, the magnitude of direct and indirect impacts of barge transportation on Kuskokwim River water use during operations is expected to be low. Because barging would continue throughout the life of the mine, and may continue beyond the life of the mine, the duration of the impact is expected to be long-term to permanent. Because the impacts affect both discrete locations and hydraulically connected waters beyond the Project Area, the geographic extent of the impact is expected to be local to regional. The context of impacts is considered common to important, as surface water is an abundant but shared and regulated resource.

Closure, Reclamation, and Monitoring

Mine Roads and Airstrip

The majority of roads at the mine site (access roads, haul roads, construction roads, etc.) would be reclaimed after mine closure. Reclamation of roads not needed for long-term monitoring of the mine site after closure would include culvert removal, and restoration and stabilization of stream channel and banks to pre-project conditions (to the maximum extent practicable). Roadbeds would be ripped and graded as necessary to eliminate the effects of compaction, recontoured to blend with the original topography, covered with a layer of growth media, and reseeded to meet the general reclamation standards (SRK 2012f). The access roads to the Angyaruaq (Jungjuk) Port and airstrip would be required for long-term monitoring of the mine site and would remain following mine closure. Periodic maintenance of road drainage features, including culverts and drainage ditches, would be conducted to maintain adequate drainage and prevent erosion.

Potential impacts to surface water hydrology from closure of roads at the mine site would include increased sedimentation and erosion during culvert removal, and ripping and regrading of the roadbed. Implementation of erosion and runoff control BMPs such as silt fences (Section 3.2, Soils) would help prevent erosion and minimize impacts during road closure. Streambanks would be revegetated as close as possible to pre-project conditions after culvert removal, which would stabilize the banks and minimize bank erosion. Therefore, direct and indirect impacts of road closure on surface water hydrology are expected to be low. Because some of the roads would be removed and some would remain after mine closure, the duration of the impact is expected to be long-term to permanent. Because the impacts would probably be contained within the Project Area, the geographic extent of the impact is expected to be local. The context of impacts is considered common to important, as surface water is an abundant but shared and regulated resource.

The mine airstrip and access road would not be reclaimed after closure as they would be used for mine site monitoring and maintenance. Surface water drainage features associated with the airstrip would be maintained as necessary to prevent erosion. Therefore, the direct and indirect impacts of the airstrip on surface water hydrology after mine closure is expected to be low. Because the airstrip would remain after mine closure, the duration of the impact is expected to be permanent. The context of impacts is considered common to important.

Ports

Angyaruaq (Jungjuk) Port. The Angyaruaq (Jungjuk) Port and facilities would be reclaimed at the end of mine operations; however, a barge landing would remain at this location for long-term monitoring needs. All mine support facilities would be removed and reclaimed, and the barge landing sheet pile wall would be removed. The area around the barge landing sheet pile wall and the port site would be recontoured and revegetated to restore pre-project functions and values to the maximum extent practicable. Therefore, the direct and indirect impacts of the Angyaruaq (Jungjuk) Port site closure on surface water hydrology after mine closure are expected to be low. Because the port will be removed at the end of mine reclamation the duration of the impact is expected to be long-term. Because the impacts would affect the immediate vicinity of the port and hydraulically connected waters beyond the Project Area, the geographic extent of the impact is considered local to regional, and because the impact affects an abundant but shared and regulated resource, the impact is considered common to important.

Bethel and Dutch Harbor Cargo and Fuel Terminals. Cargo and fuel terminals used in Bethel and Dutch Harbor would be located at existing facilities. Maintenance of surface water drainage infrastructure at these facilities would be the responsibility of the property owner after mine closure. Therefore, the direct and indirect impacts of the Bethel and Dutch Harbor Cargo and Fuel Terminals on surface water hydrology after mine closure are expected to be low. Because the Bethel and Dutch Harbor facilities will continue to exist after mine closure, the duration of the impact is expected to be permanent. Because the impacts could affect the immediate vicinity of the port and hydraulically connected waters beyond the Project Area, the geographic extent of the impact would be local to regional, and because the impact affects an abundant but shared and regulated resource, the context of the impact is common to important.

Barging

Mine fuel and cargo needs would reduce substantially after mine closure. Barge plan guidelines listed in Table 3.5-29 would be followed for barge loading; however, as barge loads reduce in size and in number of trips, the potential for barge stranding and barge-induced bank erosion would reduce, and riverbed scour would reduce closer to baseline conditions. Therefore, the direct and indirect impacts of post-closure barge transportation on the Kuskokwim River are expected to be low. Because barging would continue after mine closure, the duration of the impact is expected to be long-term to permanent. Because the impacts affect the immediate vicinity of the port and hydraulically connected waters beyond the Project Area, the geographic extent of the impact would range from local to regional, and because the impact affects an abundant but shared and regulated resource, the context of the impact is considered common to important.

Summary of Transportation Facilities Impacts

Anticipated effects from the construction, operations, and closure of transportation facilities associated with Alternative 2 would be primarily associated with drainage changes and potential increased sedimentation from construction of the Angyaruaq (Jungjuk) Port road, docks, and barging. With the exception of propeller scour, proper design and maintenance should maintain existing flow systems such that the intensity would be low; barge travel in low water conditions and in discrete critical sections of the river could result in localized medium intensity riverbed erosion that would be measurable compared to baseline effects caused by existing tugs on the river. Impacts would range from temporary (e.g. propeller scour lasting until next high flow event) to permanent in duration (e.g. Bethel bulkhead lasting beyond life of the mine), local to regional in extent, and common to important in context. Overall impacts to surface water associated with transportation facilities under Alternative 2 would be considered minor.

3.5.3.2.3 NATURAL GAS PIPELINE

Construction

As described in Section 3.5.2.3.1, the proposed natural gas pipeline under Alternative 2 would be 315 miles long between Beluga and the mine site (Figure 2.3-14 in Chapter 2, Alternatives). The proposed pipeline route would cross over 400 streams, rivers, and drainages (Table 3, Appendix G). The pipeline would be buried at all water crossings, and constructed either by open-cut or HDD methods. It is estimated that the pipeline would require 3 to 4 years to construct, with approximately 68 percent of the pipeline installed during winter months and the rest installed during summer months (SRK 2013b).

Surface Water Crossings

The construction corridor for the proposed pipeline would be 150 feet wide, which includes a 100-foot wide temporary construction ROW plus the 50-foot wide permanent ROW. During construction, vegetation would be cleared from the construction corridor to facilitate trench excavation and pipeline installation. Improperly constructed pipelines have the potential to increase erosion and, in areas underlain with permafrost, increase thermokarst conditions along the pipeline right-of-way (Section 3.2, Soils). Buried pipelines at stream crossings or within floodplains that are not installed at sufficient depths below the channel bed can alter channel hydraulics and increase erosion around the pipeline. Stabilization techniques, including gravel blankets, riprap, gabions, or geosynthetics, would be used to stabilize the channel bed and streambanks.

Open-Cut Crossings. The majority of rivers and streams along the pipeline route would be crossed by an open-cut method during winter months when flows are lowest and disturbance of the channel and streambank can be minimized. Clearing, grading, setback, and erosion control methods used at each drainage crossing will depend upon individual channel and floodplain characteristics, and crossing season. The general open-cut method involves trench excavation and pipeline installation across the stream channel, with no need to isolate and divert stream flow. Conversely, open-cut isolation or diversion methods include either flumes, culverts, or dam and pump techniques to divert stream flow around the construction area. Each of these techniques has the potential to increase sediment loading during construction and removal of the diversion feature. These crossings would be designed in cooperation with the ADF&G for protection of habitat and fish, as well as with state and federal regulatory agencies to ensure compliance with applicable water quality regulations.

Typical burial depths at open-cut stream crossings would be 4 feet, except at river crossings with high scour potential, where the pipeline would be buried up to 10 feet below the thalweg (SRK 2013b). Thalweg depths have been determined based on site-specific calculations of the 100-year event scour depth at each crossing (CH2MHill 2011c). In addition, the length of increased cover depth along river crossings assumes that active channels could move anywhere within historic floodplains. Additional geotechnical investigation would be conducted prior to final design (e.g., Section 3.2, Soils) to evaluate site-specific conditions for PHMSA permitting. Thus, the magnitude of river scour effects is anticipated to be low to medium, such that they may or may not be noticeable and the design depth of cover in high scour areas is likely to be adequate for conditions.

HDD Crossings. Six river crossings are proposed as HDD crossings. The HDD technique minimizes disturbance to the ground surface between the entry and exit points at a given crossing. Additionally, HDD eliminates the need to excavate and backfill within the stream channel. River crossings that are proposed as HDD crossings and their proposed length include:

- Skwentna River (approximately MP 50) – 2,981 feet;
- Happy River (approximately MP 86) – 3,453 feet;
- Kuskokwim River (approximately MP 240) – 7,101 feet;
- East Fork George River (approximately MP 283) – 4,532 feet;
- George River (approximately MP 290) – 2,957 feet; and
- North Fork George River (approximately MP 298) – 3,281 feet.

The three George River HDD crossings are planned for summer installation, and the Kuskokwim River, Skwentna River, and Happy River HDD crossings are planned for winter installation. Some crossings that are planned as open-cut crossings may eventually be considered for HDD; this would be determined during the final design. Fish habitat and/or permitting stipulations could also affect the final determination of HDD crossings. Potential impacts from HDD activities on streams and rivers include erosion of streambanks due to vegetation clearing and grading at HDD entrance and exit locations (see Section 3.2, Soils, where HDD is more fully described). Another potential impact includes the potential spill of drilling mud into the channel, which could result in increased sediment in the river (see Section 3.3, Geohazards and Seismic Conditions, for a discussion of the risk of HDD drilling mud loss to rivers).

The pipeline would be installed at HDD river crossings well below (typically 10s or 100s of feet below) any river scour hazard, and the ends of the HDD segments would be set back from the riverbanks at distances ranging from 400 to 3,900 feet to avoid bank erosion hazards. As HDDs typically descend beneath rivers in a gentle arc, the possibility exists for the bottom of the channel to intersect the pipe in high scour areas, resulting in exposure and potential damage to the pipe in operations, or pipe-induced hydraulic erosion in closure. Mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation, to incorporate consideration of the channel migration zone into HDD planning and design.

Temporary Crossings. Streams and rivers would be bridged temporarily to allow the passage of equipment along the ROW. These temporary crossings would be installed depending on the season, channel width, and environmental considerations at each crossing (Figures P01C-TYBD-01 through P01C-TYBD-05 of Appendix E in the Natural Gas Pipeline Plan of Development [SRK 2013b]). Equipment crossings would be temporary, and would generally be installed during ROW clearing by the civil contractor and left for use by the pipeline contractor. The crossings would have to support all construction equipment. If fish are present in the stream, then the culvert would be sloped and sized properly to allow fish passage. Certain streams without fish resources, intermittent drainages, and normally dry floodplain overflow channels may be crossed by equipment using clean rock fill in the stream bottom. Smaller streams may also be crossed using equipment mats. Modular bridges would be used to cross the larger streams and rivers, and would be positioned to avoid flood concerns and potential impacts to fish habitat. At some locations, stream channel depth and flow could require construction of temporary bridge supports. All temporary crossings including culverts and bridging would be taken out and removed once the pipeline construction is complete.

Barge Landings. Temporary barge landings are proposed where the pipeline ROW intersects the Kuskokwim River, on the east and west shores. These two sites would be used to efficiently transport pipe to the pipe storage yards (PSYs) along the ROW. Erosion control measures such as silt fencing, wattle, silt curtains, and revegetation would be implemented and maintained during construction of the landing sites. Clearing of vegetation would be followed by contouring, compaction, and placement of shoreline mats to armor against erosion and provide a foundation for equipment.

Surface Water Crossing Mitigation. Potential impacts to surface water resources would be mitigated during pipeline construction by following general procedures designed to minimize alterations to stream channel bed and banks that could lead to increased erosion and sedimentation in the channel. The following BMPs would be implemented at surface water crossings as necessary (SRK 2013b):

- Construction precautions would be taken for activities across water bodies to minimize terrain disturbance;
- Maintaining, to the maximum extent practicable, the existing surface hydrology at all water body crossings;

- Trench plugs would be used to prevent sediment-laden water from entering a surface water body;
- Trench spoil would be placed at least 30 feet from the edge of a receiving water body;
- Locating fuel storage, equipment refueling, and equipment maintenance operations at least 100 feet from surface waters;
- Stabilization of the water body shoreline would include installation of erosion control matting to armor the approach where disturbance has occurred;
- Wattles, silt fences, brush berms, or rolled erosion control products would be installed parallel to the shoreline across the entire construction ROW to minimize sediment before it enters the receiving water body (see Section 3.2, Soils, for additional erosion control measures);
- If required, temporary silt curtains would be installed and used as a turbidity barrier along the edge of water bodies. The curtains would be installed during periods of active construction;
- Stream channel banks would be revegetated and graded to their original configuration, or to a more stable configuration if original stream banks were unstable; and
- Silt-laden water produced from trench dewatering would be pumped through filter bags and discharged into an energy dissipater before entering any surface water.

At stream and river crossing approaches, temporary erosion control measures would be removed only when vegetation on the bank has progressed to the point where it can prevent erosion and keep sediment from entering the receiving water body.

Summary – Surface Water Crossings. Potential impacts to surface water from clearing and grading within the construction ROW at stream crossings includes increased runoff, erosion, and sedimentation due to removal of vegetation and soil compaction from equipment. Pipeline construction would not result in long-term alterations to stream flow, stream profile, or structural components of streams and other water bodies crossed by the pipeline (see Section 3.11, Wetlands, for description of wetlands crossing). For most stream crossings, temporary disturbances to water bodies would be limited to the construction phase. Stream beds, banks, and riparian areas would be restored to pre-project contours and configurations to the maximum extent possible. Channel banks and riparian areas would be revegetated to prevent erosion and to maintain bank stability.

Design and implementation of erosion control procedures and BMPs at each water body crossing would minimize potential impacts to surface water flow and sediment load. Additionally, potential impacts to surface water are reduced by installing the pipeline across most water bodies during winter months and low stream flow conditions. Therefore, the magnitude of the impact of pipeline construction on surface water flow and sediment load at pipeline crossings is expected to be low. The magnitude of potential scour effects would be low to medium (design adequate for conditions), and would be minimized through increased depth of cover in high hazard areas and bank stabilization techniques. The duration of the ROW runoff and erosion impacts is expected to be temporary (primarily lasting through the construction period of 3 to 4 years), and the duration of scour impacts could be long-term to permanent. Some stream crossings would require water diversion around the construction area;

however, the potential impacts to stream flow are expected to be negligible to minor, and the geographic extent is expected to be local. The context is considered common to important for this abundant but shared and regulated resource.

Water Use

Proposed Water Extraction. Water use during pipeline construction includes water supply for construction camps, ice road construction, dust control, reclamation, hydrotesting, and HDD operations. Water required for camp use during construction would be supplied from groundwater wells or clean water sources, and would be piped or trucked to a water treatment facility. There would also be water storage at each construction camp for fire suppression. Water withdrawal would be from lakes and streams, and would be planned and executed in accordance with the requirements of appropriate permits and authorizations.

Estimated annual water use requirements from surface water sources along the pipeline route are shown in Table 4, Appendix G. About 120 water extraction sites are listed along the pipeline and 19 sites along potential winter ice roads in the Susitna Valley. Eighteen of the sites would be from lakes or ponds and the remainder from streams. About three-quarters of the water extraction sites are intended for winter withdrawal only. Most sites would require withdrawal of about 1 cfs over one to two construction seasons. Final estimated quantities for specific uses would be determined during final design.

Baseline surface water data for the proposed extraction sites are also listed in Appendix G. While some pond volume data are available, there is limited stream flow information, particularly in winter, for understanding whether existing surface water supplies are adequate to meet construction needs while providing for the protection of fish. Available pertinent data consists of field observations collected during late winter surveys and pond volume estimates (RECON 2014a; SRK 2012i), the latter of which have been reduced in Table 4, Appendix G by estimated ice volume based on assuming a maximum ice thickness of 3 feet (e.g., Aldrich 1981; UAF 2014). Peak flow estimates (Table 3, Appendix G) (CH2MHill 2011c) and sporadic field-estimated flows (SRK 2012i) are not necessarily pertinent to the understanding of water availability in winter. Of the winter stream sites, only about one-third indicate the presence of open water in winter and/or other field observations of viable flow in winter; and about one-quarter are noted to have little to no flow available in winter. Thus, it is unknown whether the current water extraction plan at streams is sufficient for project needs. Of the 18 ponds or lakes, about three-quarters have volume data indicating the presence of more than adequate under-ice volume for proposed project needs; however, the presence or absence of fish is unknown at most of these. Potential restrictions due to overwintering fish in streams or ponds that could be imposed by ADF&G through the permitting process are currently unknown. However, it is reasonable to assume that collection of additional data and contingency planning would take place in final design in support of winter water use permitting. Impacts of winter water extraction on fish are further discussed in Section 3.13, Fish and Aquatic Resources.

Hydrotest Water Use. The pipeline would be pressure tested using water, air, or a combination of the two. A detailed Pressure Test Plan will be developed during final design. If water is used for pressure testing, water would be obtained from approved fresh water sources along the pipeline corridor in accordance with applicable permit requirements. Water would be withdrawn from permitted surface water sources based on source volume, depth, and fish presence. Intake hoses would be screened to prevent entrainment of fish or other aquatic species, and the withdrawal rate would be monitored to maintain adequate downstream flow. The overall volume of water required for hydrotesting is estimated to be 15 Mgal; however, the volume of water used for each hydrotest would vary, depending on segment length and type of pressure test conducted.

Used hydrotest water would be discharged to permitted discharge locations using filtration and energy dissipation devices. Hydrotest water would be analyzed for applicable water quality parameters before being discharged, as required by discharge permits. Energy-dissipating devices would be used to prevent potential impacts such as scour, erosion, suspension of sediment, and damage to vegetation. Discharge rates would be monitored to maintain the effectiveness of the filtration and energy-dissipating devices.

HDD Water Use. Estimated water use requirements for HDD operations are based on a rate of water withdrawal between 450 and 600 gpm (1.0 to 1.3 cfs). The water use estimates for each proposed HDD crossing, including estimates for HDD drill cuttings and mud volumes, are shown in Table 3.5-33. Prior to work taking place on any stream crossing where HDD would be used, a Drilling Mud Disposal Plan would be prepared as part of the overall HDD Practices, Contingency and Resource Protection Plan (SRK 2013b). Proper drilling procedures and BMPs would be implemented to contain drilling mud and prevent release to surface waters. Final setbacks between the HDD bore and water body would be established at each crossing based on site-specific conditions.

Table 3.5-33: HDD Water Use Estimates

HDD Crossing Name (Nearest MP)	Crossing Length (feet)	Estimated Total Water Requirement (gallons)	Estimated Total Volume Solids/Cuttings Needing Disposal (cubic yards)	Estimated Total Volume of Drilling Mud for Disposal (gallons)
Skwentna River (MP 50)	2,981	350,000 - 375,000	250 - 260	180,000- 200,000
Happy River (MP 86)	3,453	450,000 -500,000	280 - 290	240,000- 260,000
Kuskokwim River (MP 240)	7,101	900,000 - 925,000	590 - 600	440,000 - 460,000
East Fork George River (MP 283)	4,532	500,000 - 525,000	375 - 385	250,000 - 270,000
George River (MP 290)	2,957	325,000 - 350,000	245 - 255	160,000 - 180,000
North Fork George River (MP 298)	3,281	425,000 - 450,000	270 - 280	220,000 - 240,000

Notes:
Estimated volume ranges are based on ground condition and drilling method assumptions at each crossing; therefore, actual volumes can vary substantially and operations would be planned accordingly. Estimates would be refined during final design (SRK 2013b).
Source: SRK 2013b.

Water Use Summary. Potential impacts to surface water resources along the natural gas pipeline from lake and stream water withdrawal would include reduced water levels and stream flow. Water withdrawal for all uses would be controlled by applicable permits, which would establish limits on the amount of water withdrawn from each source and provide requirements for fish protection. Water withdrawal would be permitted and would therefore meet the requirements of ADF&G and ADNR for a water withdrawal permit. It is reasonable to assume that additional winter water extraction data collection would occur in final design, and that the rate and volume of water withdrawals would be monitored at each source to ensure permit requirements are met. Thus, the magnitude of the impacts to surface water resources is generally expected to be low. Water withdrawal would be limited to the construction phase, and is therefore expected to be temporary in duration. Impacts would be local to regional in extent, in that hydraulically connected waters beyond the immediate Project Area could be affected. Impacts would be considered common to important in context for this abundant but shared and regulated resource.

Access Roads, Pads, and Material Sites

Access/Service Roads. Pipeline construction and maintenance activities would require access to get personnel, equipment, and material to work sites during winter and summer construction seasons. Roads have the potential to impact existing drainage patterns and water quality, and to increase thermokarst conditions in areas underlain with permafrost. If located and constructed improperly, roads can block or restrict drainage during normal or flooding conditions. Additionally, roads constructed along steep slopes can increase the potential for slope failure if constructed in areas susceptible to mass movement. Roads also generate runoff that can increase sediment load that has the potential to impact surface water bodies.

Temporary crossings of streams would consist of temporary bridges and culverts. Sizeable impacts due to stream crossing structures are most likely if drainage structures are missing, undersized, or improperly constructed. The lack of a drainage structure can result in water pooling on the upstream side of the road, and more frequent than expected overtopping of the road. Overtopping of a road can lead to erosion of the road and possibly a washout. The sediment eroded from the road adds to the sediment load that may be deposited on the ground surface or within the stream channel at locations downstream from the road. Excessive sedimentation in a stream channel can destabilize the stream banks, causing the stream to widen and / or create a fish block.

Culverts would be installed using construction practices designed to prevent damage from heavy loads and to prevent erosion at the outlets. Culverts that require fish passage will be designed based on criteria used by the ADOT&PF Northern Region and described in the Memorandum of Agreement between ADOT&PF and ADF&G on the design and construction for fish passage (ADF&G and ADOT&PF 2001). By using these practices, impacts of gravel roads on water quality, erosion and sedimentation, and drainage patterns are expected to be minor.

Roads will be constructed such that they do not block drainage or present a considerable restriction during either normal stream flow conditions or flood events. To the extent practical, roads will be designed such that normal surface drainage is maintained, and that proper erosion control and slope stability is controlled. Additionally, no new roads would be retained following the construction period. All roads would be reclaimed and recontoured, temporary drainage crossing structures would be removed, and disturbed stream banks would be recontoured and revegetated. By using these practices, it is expected that the magnitude of the impacts from gravel roads and pads on surface water drainage would be low. Since roads and drainage structures would be removed and the affected areas reclaimed after the construction period, the potential impacts are expected to be temporary in duration and local in extent. Impacts are considered common to important in context.

Ice Roads and Pads. Ice roads and pads would be used for pipeline installation during winter construction months and would minimize construction impacts on the tundra or vegetative surface. Ice roads have the potential to impact existing drainage patterns and to increase erosion and sedimentation. Ice roads and pads tend to take longer to melt than the normal snowpack and can create temporary obstructions or blockages within drainage paths. Obstructions to local flow patterns can increase erosion within the drainage channel. Both obstructions and blockages can result in water pooling where such pools do not normally form, and/or increased water surface elevations during spring breakup or other flood events.

To reduce the potential for ice roads and pads to impact drainage patterns and erosion/sedimentation, ice roads and pads would be breached at known drainage paths prior to snowmelt runoff to prevent water pooling and erosion. Additionally, ice roads and ice pad BMPs would be implemented to prevent potential impacts on surface water drainage, and they would likely not be constructed in the same location from one year to the next. As a result, the magnitude of impacts from ice roads and pads on drainage and erosion is expected to be low. Since the ice roads are used during winter construction months and are likely not constructed in the same location each year of construction, potential impacts are expected to be temporary in duration and local in extent. Impacts would be common to important in context as they could affect abundant but shared and regulated resources.

Gravel Pads. Gravel pads proposed for the pipeline construction include campsite facility pads, the compressor facility pad, pads for airstrips, pads on either side of HDD crossings, pads for pipe storage yards, and other pads as required for pipeline installation. Cleared areas for campsites would range from 8 to 60 acres, with each campsite containing multiple pad sizes ranging from 4 to 10 acres, depending upon pad use. HDD pads would be 1.4 acres, one on either side of the river crossing. There are 57 PSYs proposed along the pipeline corridor, each requiring 1.5-acre gravel pads.

Gravel pads have the potential to locally impact existing drainage patterns. If located or constructed improperly, gravel pads have the potential to block or restrict drainage during normal or flood conditions. In areas underlain with permafrost, thaw settlement may occur at the toe of the pad, creating depressions for water to pool, potentially increasing thaw. Additionally, gravel pad runoff can contain a high sediment load that has the potential to impact surface water bodies and surrounding vegetation near the pad.

Gravel pads would be constructed such that they do not block or substantially restrict drainage. Gravel pads would be designed to prevent water from pooling at the toe of the pad. If gravel pads are located within a river floodplain, the pads would be designed to withstand forces that lead to erosion during an appropriate design event. SWPPPs would be developed and implemented to reduce the potential for contaminated runoff from gravel pads (Section 3.2, Soils). By using these practices, it is expected that the magnitude of impacts from gravel pads on surface water drainage would be low. Most pads would be reclaimed, though some pads (such as airstrips) would remain after the construction period; therefore the potential impacts are expected to be temporary to long-term in duration, local in extent, and common in context.

Material Sites. Gravel, sand, and rock would be acquired from approximately 70 proposed material sites located along the pipeline corridor. Excavation of borrow material could result in increased sediment loading of nearby surface water due to runoff and erosion. If excavated areas intersect groundwater, water accumulated in the pit from spring snowmelt or major precipitation events can become a source of groundwater recharge. Conversely, groundwater discharge may be a source of water accumulation in the pit. Potential impacts of the construction and operation of material sites on surface water resources include: temporary and permanent disturbance of the ground surface and cover, soil compaction due to use of heavy equipment, excavation of borrow areas, material storage, and use of water for construction activities, such as dust control. Storage of excavated material may result in increased sedimentation of surface water, or a reduction in flood storage capacity if located within a floodplain. To reduce the impact of a material mine site on the surface water resources, mine sites would be constructed with a berm around the perimeter of the pit to reduce surface water runoff entering the pit. To reduce the potential for increasing thaw settlement along the outside of the berm in areas underlain with permafrost, the outside of the berm will be designed so that it does not create excessive pooling of water. Runoff and erosion control BMPs would be developed and implemented at each material site to minimize runoff and erosion. Thus the magnitude of the impacts of material sites on surface water resources is expected to be low. All material sites would be reclaimed consistent with approved reclamation plans for each site; therefore potential impacts are expected to be temporary to long-term. Impacts would be local in extent, and are considered common to important in context.

<u>Operations and Maintenance</u>

A pipeline inspection, surveillance and monitoring program would be designed to observe surface conditions on and adjacent to the ROW for indications of leaks and any other factors affecting safety and operation. Monitoring at river and stream crossings would include documentation of rehabilitated streambed and bank condition, stream migration activity, and channel scour. Inspections of surface conditions around the pipeline would occur at least twice each calendar year, typically once after breakup and once before deep snowfall. Inspections may also be needed following the occurrence of major storm events.

While the temperature of the pipeline is expected to follow seasonal ground temperatures at low-flow rates, the potential exists for cooled natural gas to create localized chilled pipeline sections with temperatures less than the ambient ground temperature. In this event, the potential for altering the thermal regime of streams at the pipeline crossing exists. This could result in the formation of ice dams and aufeis, caused by the stream bottom over the buried pipe having a colder temperature than the surrounding water. The formation of ice dams or aufeis could alter stream flow direction and velocity, potentially causing stream bank erosion and a fish passage block.

Between MP 84 and MP 97, the pipeline would cross the Iditarod National Historic Trail corridor at 13 locations and be co-located with it for about 4 miles (Table 3.16-5, Recreation). Over the course of a winter, localized glaciation or aufeis, usually extending less than one-quarter mile along the trail, is known to occur in this area, and can accumulate about 1 to 10 feet thickness of solid ice (BLM 2015d), a situation which could be exacerbated by the co-located ROW near stream crossings. Glaciation can be hazardous for the passage of foot travelers, sled dog teams, bicyclists, skiers, and snowmachiners, due to slippery cross slopes usually associated with the flowage. The glaciation can be from both natural and manmade causes. One natural example is the "Post River Glacier" found on the Iditarod National Historic Trail immediately north of the Post River, about 10 miles north of Rohn. While the Post River does not intersect the Alternative 2 pipeline route, similar conditions could occur in other parts of the Alaska Range where streams intersect the pipeline route. Numerous examples of manmade glaciation are found on the Takotna-Ophir Road portion of the trail northwest of McGrath. The actual amount of glaciation occurring on any given year is directly related to the amount of precipitation in the preceding summer and fall, the amount of insulating snow cover, thaw episodes, and number and length of subzero temperature episodes. BMPs and ESC measures emplaced to promote non-erosive drainage from existing and new water sources and pathways, as well as regular monitoring and maintenance during operations (Section 3.2.3.2.3, Soils, Erosion), are expected to minimize these effects along the ROW and co-located Iditarod trail sections and crossings.

Potential impacts to surface water resources during the operations phase of the pipeline would include the alteration of stream flow and increased sedimentation from erosion. Stream banks at crossings would be susceptible to erosion from rain, runoff, and high water events; however, the potential for these impacts to occur would be highest immediately following the construction period. Additional details on preventative and corrective maintenance is provided in Section 3.2, Soils. As stabilization and rehabilitation of disturbed areas takes effect, the potential impacts at the crossings would decrease over time. If ice dams or aufeis form in the channels as a result of cold pipe sections, the impact on surface water resources could be medium, in that they could alter drainage patterns, and could last for several years beyond the life of the project. Potential impacts of the pipeline crossing wetlands is discussed in Section 3.11, Wetlands, and the potential impacts of the pipeline on subsurface flow is discussed in Section 3.6, Groundwater Hydrology. Thus the magnitude of the impacts to surface water resources during pipeline operations and maintenance is expected to be low to medium. Operation and maintenance of the pipeline would occur over the life of mine operation; therefore, potential impacts are expected to be temporary to long-term in duration as potential aufeis would likely return to normal conditions several seasons or years following abandonment. Effects are expected to be local in extent, and common to important in context.

<u>Closure, Reclamation, and Monitoring</u>

The Stabilization, Rehabilitation and Reclamation (SRR) Plan would also include final reclamation actions at closure of pipeline (SRK 2013b) (see also Section 3.2, Soils). Closure and abandonment plans would be developed in accordance with all pertinent regulations and would follow applicable BMPs related to surface water resources. All below grade pipe would be abandoned in place, including the HDDs, and all above grade pipe and pipeline structural facilities would be removed. All gravel pads would remain and topsoil would be returned and the areas would be revegetated. Surfaces would be scarified in preparation for revegetation. Temporary and permanent erosion control measures would be installed (Sections 3.2.3.2.1 and 3.2.3.2.3, Soil Disturbance and Erosion).

No new roads would be retained for operation and maintenance purposes following construction. All roads would be reclaimed as required following established procedures and the approved SRR Plan. All new airstrips, built for pipeline construction purposes and used during operations, would also be reclaimed by the same procedures followed for reclaiming gravel pads. This would include any airstrip access roads.

The two Kuskokwim River barge landings at Kuskokwim East and Kuskokwim West would be established for pipeline construction purposes; however, landings may be reopened during operations for maintenance purposes. These landings would be reclaimed when no longer needed following established procedures and the approved SRR Plan. The areas would be regraded similar to pre-construction, and revegetated. Temporary and permanent erosion control measures would be installed.

Potential impacts during pipeline closure include increased runoff due to soil compaction from equipment used during pipeline abandonment activities. The SRR Plan will detail applicable BMPs for final reclamation of all gravel pads, stream banks, and drainages. The pipe cover design basis for trenched stream crossings is based on the depth below the stream thalweg (deepest section of the stream), as described above in the pipeline construction section. It is possible that a flood larger than the design flood (100-year event) could occur in post-closure, in which case the abandoned pipeline could be uncovered and impact the river or stream by causing localized erosion and flow pattern changes. These effects are not expected to cause substantial changes to nearby land uses or environments. Post-closure monitoring of stream crossings is recommended as an adaptive management measure for the SRR plan (Chapter 5, Impact Avoidance, Minimization, and Mitigation) in order to identify potential scour and lateral stream migration that could uncover the pipeline. Thus, the magnitude of the impacts of pipeline abandonment and reclamation on surface water resources would range from low to medium. Potential impacts from the final reclamation of stream banks, roads, gravel pads, material sites; the installation of temporary and permanent erosion control measures as necessary; and the abandonment of the buried pipeline, are expected to be temporary to permanent in duration, local in extent, and common in context.

<u>Summary of Natural Gas Pipeline Impacts</u>

Anticipated effects from the pipeline component of the project under Alternative 2 would include the potential for increased runoff, erosion, and sedimentation during construction, operations, and closure; scour causing potential exposure and damage to the pipeline in operations, or streambed alterations in closure; water use for hydrotesting or ice roads; and potential aufeis development. Impacts would mostly be of low to medium intensity. Impacts could range from temporary (e.g. ROW runoff effects lasting only as long as the period of construction) to permanent (e.g., localized scour effects in post-closure) in duration. Monitoring stream crossings during the post-closure period would help minimize the intensity and duration of potential impacts from scour and lateral stream migration (Chapter 5, Impact Avoidance, Minimization, and Mitigation). The extent of surface water effects would range from local (close vicinity of the pipeline ROW) to regional (e.g. surface water use affecting hydraulically connected waters beyond the Project Area). The effects are considered common to important in context for this abundant but shared and regulated resource. Overall impacts to surface water resources associated with the natural gas pipeline under Alternative 2 would be considered minor.

3.5.3.2.4 CLIMATE CHANGE

Predicted overall increases in precipitation and changes in patterns of surface water distribution have the potential to influence the projected effects of the Donlin Gold Project on surface water hydrology. These effects are tied to changes in water resources as discussed in Section 3.26.4.2.2, Climate Change.

3.5.3.2.5 SUMMARY OF IMPACTS – ALTERNATIVE 2

Impacts to surface water quantity and drainage under Alternative 2 would range from low intensity (e.g., vegetation removal, soil compaction, and installation of drainage structures at stream crossings) to high intensity (e.g., decreased runoff contribution from American Creek and Anaconda Creek to Crooked Creek), although the intensity of some stream flow effects would be reduced to low to medium in closure. Potential impacts to surface water resources under Alternative 2 are summarized in Table 3.5-34. The duration of impacts could range from temporary (e.g. ROW runoff effects lasting only as long as the period of construction) to permanent (e.g., Crooked Creek flow reductions due to pit lake water level maintenance). The extent of impacts would range from local (immediate vicinity of project facilities) to regional (potentially affecting hydraulically connected waters beyond the Project Area). Surface water hydrology is considered common to important in context, as it is an abundant but shared and regulated resource. Net overall impacts would be minor (mine site post-closure, transportation, and pipeline) and minor to major (construction and operations at mine site).

These effects determinations take into account impact-reducing design features (Table 5.2-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) proposed by Donlin Gold as well as Standard Permit Conditions and BMPs (Section 5.3, Impact Avoidance, Minimization, and Mitigation) that would be implemented.

Design features that are most important for reducing impacts to surface water hydrology include the following:

- Post-closure sediment controls would include site grading and capping of erodible material, revegetation, and re-routing of surface runoff to reestablish natural conditions;
- The project design at the mine site includes water management strategies that would maintain flow and storage within the design capacity of structures, provide flexibility for extra storage in high precipitation years, and sufficient water supplies for processing in low precipitation years;
- The project design includes stream flow monitoring and dam inspections to continually provide data for water management and dam safety purposes;
- The barge operations system was designed to avoid the need for river dredging;
- Donlin would implement barge guidelines for operating at certain river flow rates, and conduct ongoing surveys of the Kuskokwim River navigation channel to identify locations that should be avoided to minimize effects on bed scour and the potential for barge groundings. As part of the proposed operation, equipment will be available to free or unload/lighter barges in the event of groundings. The equipment will be available as part of ongoing operations, it will not all be dedicated standby equipment; and
- The project design includes use of BMPs at pipeline stream crossings to minimize alterations of the stream bed and bank erosion. It also includes design of pipeline depth of burial at stream crossings to avoid scour exposure of the pipe.

Standard Permit Conditions and BMPs related to surface water hydrology include:

- Implementation of Stormwater Pollution Prevention Plans (SWPPPs) and/or Erosion and Sediment Control Plans;
- Preparation and implementation of a Stabilization, Rehabilitation, and Reclamation Plan; and
- Monitoring of water withdrawals to ensure permitted limits are not exceeded,

Additional Mitigation and Monitoring for Alternative 2

The Corps is considering additional mitigation (Table 5.5-1 in Section 5.5, Impact Avoidance, Minimization, and Mitigation) to reduce the effects presented above. Additional mitigation measures related to surface water hydrology include the following:

- Restore flat-to-gently sloping wetlands by removal of fill at project closure where feasible. Removed fill would be moved to approved upland areas. Details would be developed as Donlin Gold's Conceptual Compensatory Mitigation Plan is developed and as design and permitting progress. Those details do not exist at the DEIS stage;
- Replace culverts along the mine access road with low water crossings at closure to minimize long-term effects of extreme precipitation events and climate change; and
- Develop an HDD plan for each HDD river crossing to reduce potential effects from "frac-out," which can occur if drilling fluids are lost into fractures or voids and released into the river above.

The Corps is considering additional monitoring and adaptive management (Table 5.7-1 in Section 5.7, Impact Avoidance, Minimization, and Mitigation) to reduce effects on surface water. These include the following:

- Include monitoring and inspection of stream banks on Crooked Creek and tributaries where water will be discharged, and response with appropriate streambank protection, in order to ensure erosion of stream banks does not occur;
- To characterize winter low flow conditions during construction, operation, and closure, expand current surface water monitoring program to include quarterly monitoring, evenly spaced and including winter monitoring;
- Recommend adding the upstream monitoring site DCBO as control point for monitoring water quality and discharge;
- The groundwater flow model should be reexamined 3 years after the commencement of pit dewatering to minimize uncertainty about dewatering effects, with a 5-year review frequency thereafter, or when noteworthy unexpected conditions are encountered. Unexpected conditions should be used to revise projections and adjust management plans as needed. As required by permit conditions, relevant groundwater data (such as production rates and water table levels) should be collected as mining progresses to facilitate model revisions;
- Monitoring of bank erosion upstream and downstream of Jungjuk port, and consideration of streambank protection as part of adaptive management plan if warranted. This may include installation of geotextile matting, riprap armoring or

methods from ADF&G's Streambank Revegetation and Protection Manual (Walter et al. 2005) to reduce the effects of eddy formation, scour, and bank erosion during flood events (BGC 2014e); and

- Conduct pre-construction surveys at stream crossings along the mine access road of suitable detail to be able to monitor erosion and deposition after culvert placement.
- To minimize the effects of climate change, reexamine the continuing applicability of key portions of the water balance model on approximate 10-year intervals as determined by the data collected and operational or closure conditions and experiences. For example, current mine plans for the pit lake during closure indicate that the water level would be monitored and pit lake model recalibrated as data become available. It is recommended that climate change precipitation predictions also be reevaluated periodically in post-closure, and incorporated into water balance and groundwater model updates, in order to adequately anticipate climate change effects on pit filling and other project structures such as reclaim components.

If these mitigation and monitoring measures were adopted and required, uncertainties in the range of summary impact ratings for surface water hydrology would be reduced, and the ratings themselves could be reduced to minor, as the intensity of impacts could be reduced to low or medium.

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Table 3.5-34: Summary of Surface Water Impacts for Alternative 2

Project Component	Impact Type/Facility	Magnitude or Intensity	Duration	Extent	Context	Summary Impact Rating[1]
Mine Site	Snow Gulch Reservoir	**Low** (14% flow reduction below dam under average precipitation conditions, within historical seasonal variation) **High** (below average precipitation conditions requiring more water from reservoir for process water)	**Long-Term** (dam removed at end of mine operations, streamflow returned to pre-mining conditions)	**Local to Regional** (small impact on Crooked Creek and negligible impact on Kuskokwim River)	**Common to Important** (impacts affect an abundant but shared and regulated resource [Crooked Creek])	
	American Creek (WRF, Mine Pit Groundwater Dewatering Wells, and SOB)	**High** (100% of American Creek flow diverted or stored)	**Permanent** (extend beyond reclamation)	**Local to Regional** (impacts would extend several miles downstream on Crooked Creek, but have negligible impact on Kuskokwim River)	**Common to Important** (impacts affect an abundant but shared and regulated resource [Crooked Creek])	
	Anaconda Creek (TSF, SRS)	**High** (67% flow reduction, exceeds historic seasonal variation)	**Permanent** (extend beyond reclamation)	**Local to Regional** (impacts would extend several miles downstream on Crooked Creek, but have negligible impact on Kuskokwim River)	**Common to Important** (impacts affect an abundant but shared and regulated resource (Crooked Creek))	
	Mine Site Facilities Runoff	**Low** (changes to runoff would be within the limits of historic seasonal variation)	**Long-Term** (diversion of runoff would last through the mine operations phase)	**Local** (diversions are limited to discrete portions of the Project Area)	**Common to Important** (impacts affect an abundant but shared and regulated resource)	
	Crooked Creek (flow reductions) – Operations	**Low to Medium** (flow reduced by 28% near mine and 9% near Bell Creek, likely within historical seasonal variation) **High** (flow reduced by 100% near mine and 31% near Bell Creek could exceed historical seasonal variation under low flow conditions and high hydraulic conductivity of the bedrock aquifer)	**Long-Term** (flow reductions would last through the mine operations phase)	**Local to Regional** (flow reductions decrease downstream and would not affect Kuskokwim River)	**Common to Important** (impacts affect an abundant but shared and regulated resource)	
	Crooked Creek (flow reductions) – Post Closure	**Low to Medium** (e.g., monthly flow changes range from -12% to +21% just below mine near Crevice Creek, likely within historical seasonal variation)	**Permanent** (due to pit lake pumping and treated water discharge in perpetuity)	**Local to Regional** (flow reductions decrease downstream and would not affect Kuskokwim River)	**Common to Important** (impacts affect an abundant but shared and regulated resource)	
	Crooked Creek – Channel Dimensions	**Low** (dimension changes less than 3 to 12%)	**Permanent** (parallels duration of flow effects)	**Local to Regional** (dimension changes decrease downstream and would not affect Kuskokwim River)	**Common to Important** (impacts affect an abundant but shared and regulated resource)	
Mine Site Summary		**Low to High**	**Long-Term**	**Local to Regional**	**Common to Important**	**Minor to Major** (during construction and operation), **Minor** (after closure)

Table 3.5-34: Summary of Surface Water Impacts for Alternative 2

Project Component	Impact Type/Facility	Magnitude or Intensity	Duration	Extent	Context	Summary Impact Rating[1]
Transportation	Roads, Bridges, Airstrip, Main Camp	**Low** (within the limits of historic seasonal variation)	**Long-Term to Permanent (**roads and some pads would be in place beyond the life of the mine)	**Local** (limited to discrete portions of the Project Area)	**Common** to **Important** (impacts affect an abundant but shared and regulated resource)	
	Angyaruaq (Jungjuk), Bethel, and Dutch Harbor Ports	**Low** (changes in water quantity and velocity would be within the limits of historical seasonal variation)	**Long-Term** (Angyaruaq [Jungjuk] Port) **to Permanent (**Bethel and Dutch Harbor would be in place beyond the life of the mine)	**Local to Regional** (impacts would in the immediate vicinity of the ports and hydraulically connected waters beyond the Project Area)	**Common** to **Important** (impacts affect an abundant but shared and regulated resource)	
	Kuskokwim River (Barging)	**Low** (Barge operation guidelines developed to minimize impacts from barge traffic) **Medium** (local flow alterations at the riverbed above baseline effects from existing tug propeller scour)	**Temporary** (propeller scour lasting until next high flow event) **to Permanent** (greatly reduced barging extending beyond the life of the project)	**Local to Regional** (impacts at 8 critical sections along the river over 199 miles and hydraulically connected waters beyond the Project Area)	**Common** to **Important** (impacts affect an abundant but shared and regulated resource)	
Transportation Summary		**Low to Medium**	**Temporary to Permanent**	**Local to Regional**	**Common to Important**	**Minor**
Pipeline	Surface Water Crossings (Open Cut, Temporary, HDD)	**Low** (water bodies crossed during winter months and low stream flow conditions) **Low to Medium** (potential scour effects)	**Temporary** (runoff and erosion in ROW lasting through construction period of 3 to 4 years) **Long-Term to Permanent** (duration of potential scour impacts)	**Local** (within footprint of ROW)	**Common** to **Important** (impacts affect an abundant but shared and regulated resource)	
	Water Use (Extraction for HDD, Hydrostatic Testing)	**Low** (assuming winter water availability data collection in final design, and rate and volume withdrawn monitored to meet permit requirements)	**Temporary** (water withdraw during construction phase).	**Local to Regional**, (hydraulically connected waters beyond the immediate Project Area)	**Common** to **Important** (impacts affect an abundant but shared and regulated resource)	
	Pipeline Access and Service Roads	**Low** (roads reclaimed, temporary drainage crossing structures removed, disturbed stream banks recontoured and revegetated)	**Temporary** (during construction only)	**Local** (within pipeline ROW)	**Common to Important** (impacts affect an abundant but shared and regulated resource)	
	Ice Roads and Ice Pads	**Low** (not constructed in same location each year)	**Temporary** (not constructed in same location each year)	**Local** (not constructed in same location each year)	**Common to Important** (impacts affect an abundant but shared and regulated resource)	
	Gravel Pads	**Low** (constructed such that they do not block or substantially restrict drainage)	**Temporary** (most reclaimed after construction) **Long-Term** (airstrips)	**Local** (most reclaimed after construction)	**Common** (most reclaimed after construction)	
	Material Sites	**Low** (constructed to minimize runoff and erosion)	**Temporary to Long-Term** (reclaimed after construction)	**Local** (reclaimed after construction)	**Common to Important** (impacts affect an abundant but shared and regulated resource)	
Pipeline Summary		**Low**	**Temporary to Long-Term**	**Local**	**Common to Important**	**Minor**

Notes:

1 The summary impact rating accounts for impact reducing design features proposed by Donlin Gold and Standard Permit Conditions and BMPs that would be required. It does not account for additional mitigation measures the Corps is considering.

3.5.3.3 ALTERNATIVE 3A – REDUCED DIESEL BARGING: LNG-POWERED HAUL TRUCKS

3.5.3.3.1 MINE SITE AND NATURAL GAS PIPELINE

Effects on surface water resources under Alternative 3A would be the same as Alternative 2 for the mine site and pipeline components.

3.5.3.3.2 TRANSPORTATION FACILITIES

Under Alternative 3A, the number of fuel barge round trips per season would reduce to 19, compared to 58 trips for fuel under Alternative 2. Potential impacts to the Kuskokwim River under Alternative 3A would be similar to those listed under Alternative 2; however, the magnitude of those impacts would decrease due to the reduction in fuel barge trips and decreased likelihood that low water travel would be required to meet shipping requirements. The potential for barge stranding would decrease, the potential for barge-induced bank erosion would decrease, and the scour potential from propeller wash would decrease under Alternative 3A.

The reduction in diesel fuel requirements for the mine site under Alternative 3A would also reduce diesel storage capacity needed at Dutch Harbor, Bethel, and Angyaruaq (Jungjuk) ports. The potential impacts to surface water resources from increased runoff and erosion during construction and operations at these locations would be less than those under Alternative 2 as fuel storage facility footprints would be smaller. Runoff and erosion control BMPs implemented at these facilities during construction and operations would be the same as those listed under Alternative 2. Therefore, the magnitude of the direct and indirect impacts of barge transportation and transportation facilities on the Kuskokwim River under Alternative 3A during mine construction and operations is expected to be low.

3.5.3.3.3 SUMMARY OF IMPACTS – ALTERNATIVE 3A

The potential impacts under Alternative 3A would be the same as those described under Alternative 2 for the mine site and natural gas pipeline components of the Project. As described above, the reduction in the number of barge trips under Alternative 3A would reduce the magnitude of the potential impacts to the Kuskokwim River as there would be a decrease in barge stranding potential, barge-induced bank erosion potential, and scour from propeller wash. Impacts associated with climate change would be the same as those discussed for Alternative 2. The implementation of Alternative 3A would have minor to moderate direct and indirect impacts on surface water in the proposed Project Area.

The effects determinations take into account applicable impact-reducing design features and BMPs, as discussed in Alternative 2. Additional mitigation and monitoring measures have been identified to reduce effects to surface water, and if they were adopted the intensity of impacts could be reduced to low or medium, as in Alternative 2, and the summary impact rating would be similar to Alternative 2, minor.

3.5.3.4 ALTERNATIVE 3B – REDUCED DIESEL BARGING: DIESEL PIPELINE

3.5.3.4.1 MINE SITE

Alterations to surface water resources for Alternative 3B are generally the same as Alternative 2 for construction, operation, and closure, with some minor reductions in area developed for fuel storage.

3.5.3.4.2 TRANSPORTATION FACILITIES

Roads

Effects of road construction on surface water quantity under Alternative 3B would be similar to those described under Alternative 2. The diesel pipeline would follow an existing overhead transmission line corridor for approximately 18 miles from the Tyonek area to MP 0 of the natural gas pipeline corridor (Figure 2.3-40 in Chapter 2, Alternatives), then follow the same ROW as the natural gas pipeline route under Alternative 2. Access/service roads would be constructed as necessary between Tyonek and MP 0; however, these roads would not be a notable addition to the roads constructed along the 315-mile pipeline corridor between MP 0 and the mine site. Some airstrips and shoofly roads would remain during operations to support spill response needs, which would be longer term than under Alternative 2. Surface water drainage associated with these roads and airstrips would be maintained during operations and disturbed areas would be revegetated where needed; however, the beneficial effects of full reclamation would be delayed until the closure period, as compared to Alternative 2 in which reclamation would occur immediately following construction. Because there would be similar infrastructure to Alternative 2, the magnitude of the impact is anticipated to be low, and to be the same as Alternative 2.

Ports

Angyaruaq (Jungjuk), Bethel, and Dutch Harbor Ports. The Angyaruaq (Jungjuk) Port site, including facilities footprint and barge landing, under Alternative 3B would be similar to that of Alternative 2 as fuel storage capacity would be needed at this site during the construction period. Diesel fuel storage requirements at the Dutch Harbor and Bethel fuel terminals would be reduced under this alternative, and the construction of additional fuel storage capacity at Dutch Harbor and Bethel fuel terminals would be less than that required for Alternative 2. Thus, the magnitude of the impact is anticipated to be low, and to be the same as Alternative 2.

Tyonek North Foreland. The existing North Foreland Barge Facility dock in Tyonek would be expanded under Alternative 3B. The expansion would include construction of a temporary barge landing adjacent to the dock to support dock extension and pipeline construction. The temporary barge landing area would be constructed in an area previously developed, and temporary fill placement may be necessary for barge off-loading. The existing dock extends approximately 1,500 feet from shore, and in order to accommodate draft requirements for fuel tankers supplying diesel fuel to the pipeline, the dock would be extended another 1,500 feet (Figure 2.3-39 in Chapter 2, Alternatives). The water depth at this location is sufficient such that it would not be necessary to dredge at the dock or in shipping channels, either initially or for maintenance.

Navigation charts indicate that large boulders protrude above the sea floor in the vicinity of the dock extension that would likely be a navigation hazard. A bathymetric survey would be completed prior to design and construction to identify the exact location of these boulders, which would then be removed during construction. These development activities would require a Corps Section 10 of the Rivers and Harbor Act permit and a tidelands and submerged land lease from the ADNR.

Potential impacts to surface water resources from increased runoff due to vegetation removal and soil compaction would be similar to those described under Alternative 2 except that the receiving waters would be Cook Inlet. Erosion and stormwater control BMPs would be implemented onshore during construction and operations to prevent erosion and subsequent sedimentation from entering Cook Inlet. Similar to surface water quantity disturbances under Alternative 2, the additional impacts are expected to be local in extent, and have an overall impact rating of minor.

Barging

Kuskokwim River. Under Alternative 3B, fuel would be barged on the Kuskokwim River during construction; however, upon completion of the diesel pipeline, only cargo would be barged up the river. Potential impacts to the Kuskokwim River under Alternative 3B would be similar to those listed under Alternative 2; however, the magnitude of those impacts would decrease due to the elimination of fuel barge trips and less likelihood of barge travel in low water conditions. The potential for barge stranding would decrease, the potential for barge-induced bank erosion would decrease, and the scour potential from barge propeller wash would decrease under Alternative 3B. Thus, the potential impacts to the Kuskokwim River from barging are expected to be minor under Alternative 3B.

Cook Inlet. Diesel fuel for the diesel pipeline would be delivered year round by tanker to the Tyonek North Forelands Facility. Storms, extreme tides, sea ice, and strong currents would be challenges to navigation in Cook Inlet. In addition, tankers berthed during winter months would need to be able to withstand potential increased ice load. Cook Inlet characteristics, including tidal fluctuations as high as 35 feet, currents up to 10 knots, ice flows, and icing conditions, would be potential challenges when docking and transferring fuel. Fuel transfers under these conditions at the Tyonek facility have the potential for spills and other risks during docking procedures. The new tanker berth and pile support system at the Tyonek facility would be designed to accommodate site-specific tide, ice, and sea bottom conditions. Diesel fuel transportation and transfer BMPs would be designed and implemented under Alternative 3B to prevent fuel spills and vessel grounding. Procedures and guidelines are continually updated to operate in Cook Inlet, and tug boats would be used to assist tankers during icing conditions. Additionally, the USCG has approved the Cook Inlet Regional Citizens Advisory Council's annual recertification, which allows the spill response organization to continue its mission in promoting safe marine transportation and oil facility operations within Cook Inlet (Alaska Journal 2013).

Potential impacts to Cook Inlet from diesel fuel transportation and transfer would include tanker grounding and fuel spills; however, these potential impacts would be managed through the design and implementation of current procedures, guidelines, and BMPs. Therefore, the magnitude of the direct and indirect impacts of diesel fuel transportation and transfer on Cook Inlet during construction and mine operations is expected to be low. Because diesel fuel transportation in Cook Inlet would occur during mine operations and closure, the duration of the impacts is expected to be long-term. Because the impacts could affect hydraulically connected waters beyond the Project Area, the geographic extent of the impact is expected to be regional, and because the impacts affect an abundant but shared resource the context is considered common to important.

3.5.3.4.3 DIESEL PIPELINE

Pipeline ROW and Trench

The diesel pipeline would follow the same ROW corridor described under Alternative 2, therefore the number of stream crossings and stream crossing methods (HDD versus open trench), as well as erosion and stormwater control BMPs implemented during construction and operations, would be the same as those described under Alternative 2. The diesel pipeline would originate near Tyonek North Foreland and would traverse an additional 18 miles to reach MP 0 of the natural gas pipeline corridor, crossing an additional six streams/rivers along this section. Five of the six streams would be crossed using an open trench method, and the Beluga River would require HDD. The potential impacts on surface water quantity and flow, and potential impacts from scour on the pipe, would essentially be the same for the diesel pipeline as with the natural gas pipeline under Alternative 2. Thus, the magnitude of effects would be similar to Alternative 2, and is expected to remain low to medium. Additional discussion of the hydrologic effects of a pipeline diesel spill is presented in Section 3.24, Spill Risk.

Water Use

Water use during construction of the diesel pipeline would essentially be the same as those described under Alternative 2; however, water requirements for pressure testing the pipeline, ice road, and ice pad construction would increase some as the pipeline diameter would be larger and the pipeline would be longer. Additional fresh water sources would be required along the 19-mile section between Tyonek and MP 0 of the natural gas pipeline corridor, and the sources of water identified under Alternative 2 would also be used under Alternative 3B. As described under Alternative 2, the rate and volume of water withdrawn would be monitored at each source to ensure permit requirements are met; thus the magnitude of the impacts to surface water resources is expected to be low under Alternative 3B.

3.5.3.4.4 SUMMARY OF IMPACTS – ALTERNATIVE 3B

The implementation of Alternative 3B would have minor to moderate impacts on surface water in the proposed Project Area; while barging impacts would decrease, the range of effects including the mine site would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

The effects determinations take into account applicable impact-reducing design features and BMPs, as discussed in Alternative 2. Additional mitigation and monitoring measures have been identified to reduce effects to surface water, and if they were adopted the intensity of impacts could be reduced to low or medium, as in Alternative 2, and the summary impact rating would be similar to Alternative 2, minor.

3.5.3.5 ALTERNATIVE 4 – BIRCH TREE CROSSING (BTC) PORT

3.5.3.5.1 MINE SITE AND NATURAL GAS PIPELINE

Effects on surface water resources under Alternative 4 would be the same as discussed under Alternative 2 for the mine site and pipeline components.

3.5.3.5.2 TRANSPORTATION FACILITIES

Roads and Ports

Under Alternative 4, the Kuskokwim River port site would be located at BTC, approximately 69 river miles downstream from the Angyaruaq (Jungjuk) Port site described under Alternative 2. The BTC Road between the BTC Port and the mine site would be 76 miles long, which is about 2.5 times the length of the Alternative 2 mine access road (Figure 3.5-9). The BTC mine access road would be a two-lane, 30-foot wide, all-season gravel road used for mine support traffic, as proposed under Alternative 2. The number of stream crossings under Alternative 4 is slightly higher than that of Alternative 2. Preliminary field reconnaissance of the BTC Road indicates that the road would cross 43 streams; of these, 8 would require bridges and 35 would require culverts (compared to 40 streams, 6 bridges, and 34 culverts under Alternative 2) (RECON 2007c, 2011b). Additional drainage features (such as intermittent or ephemeral drainages) may exist along the route that would require installation of a culvert to convey flow; however, additional reconnaissance during final design would be required to identify these types of features.

Even though the BTC Road is longer than the mine access road, potential impacts to surface water quantity and drainage are expected to be similar to those described under Alternative 2, as runoff and erosion control BMPs at stream crossings would be implemented during the construction, and operations and maintenance phases of the mine. The BTC Road would be constructed to maintain existing surface water flow systems and the impact on magnitude of the flow is likely to be within the limits of historic seasonal variation. Thus, the magnitude of the direct and indirect impacts on water quantity is expected to be low under Alternative 4.

The BTC Port would be constructed on the north side of the Kuskokwim River, and would occupy a footprint of about 65 acres (Figure 2.3-41 in Chapter 2, Alternatives), which is more than twice the size of the Angyaruaq (Jungjuk) Port described under Alternative 2. Similar to the Angyaruaq (Jungjuk) Port site, a sheet pile wall would be installed in the Kuskokwim River, and fill material would be placed behind the wall, to create an area for cargo container storage and handling. The potential impacts of the BTC Port facility during construction and operations on surface water runoff and erosion, and Kuskokwim River flows, would be minimized by implementing the same BMPs for erosion control described under Alternative 2. Surface water flow systems would be maintained and changes in water quantity and velocity are expected to be within the limits of historical seasonal variation. Thus, the magnitude of the direct and indirect impacts on water quantity and velocity is expected to be low.

Barging

Under Alternative 4, the same amount of fuel and cargo would be barged on the Kuskokwim River during construction and operations as under Alternative 2; however, the barge distance would be approximately 75 river miles shorter. Potential impacts to the Kuskokwim River under Alternative 4 would be similar to those listed under Alternative 2, although the magnitude of those impacts would decrease due to the shorter barge distance, shorter shipping season, fewer critical (shallow) river sections (Figure 3.5-29), and less need for barging in low water conditions. There would be a total of three critical sections along the 124-mile river distance between Bethel and BTC (including those at both ports). The potential for barge stranding would decrease, the potential for barge-induced bank erosion would decrease, and the scour potential from barge propeller wash would decrease under Alternative 4. Thus, the potential impacts to the Kuskokwim River from barging are expected to remain low under Alternative 4.

3.5.3.5.3 SUMMARY OF IMPACTS – ALTERNATIVE 4

The implementation of Alternative 4 would have minor to moderate direct impacts on surface water in the proposed Project Area; while barging impacts would decrease, the range of effects including the mine site would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

The effects determinations take into account applicable impact-reducing design features and BMPs, as discussed in Alternative 2. Additional mitigation and monitoring measures have been identified to reduce effects to surface water, and if they were adopted the intensity of impacts could be reduced to low or medium, as in Alternative 2, and the summary impact rating would be similar to Alternative 2, minor.

3.5.3.6 ALTERNATIVE 5A – DRY STACK TAILINGS

3.5.3.6.1 MINE SITE

Under Alternative 5A, tailings would be dewatered in a filter plant using specialized equipment to produce a partially saturated, compactable material. Alternative 5A would include an additional dam for holding the dry stack tailings located east of the TSF dam described under Alternative 2, which would be utilized as a water dam for an operating pond under Alternative 5A (Figure 3.5-32). The dewatered tailings would be delivered behind the upper (eastern) TSF dam by conveyor or truck and spread and compacted in layers using bulldozers. Process-affected water removed from the tailings would be transported by pipeline to the operating pond located between the main dam and upper dam. Reclaimed water from the operating pond would be pumped back to the process plant for reuse. The dry stack alternative and the TSF described under Alternative 2 are essentially equivalent with respect to disturbed footprint area.

Two options are considered under Alternative 5A:

- Option 1: Unlined Dry Stack - The dry stack tailings alternative facility would be placed on the existing overburden material with removal of ice-rich or saturated overburden. The foundation material will typically consist of colluvium and loess, with alluvial deposits in the valley bottom. A rock underdrain would be placed in the major tributaries of the facility as described under Alternative 2.

- Option 2: Lined Dry Stack - The dry stack tailings would be underlain by a pumped overdrain layer throughout the footprint, with an impermeable LLPDE liner below. The rock underdrain and foundation preparation would be completed in the same manner as Alternative 2.

Option 1: Unlined Dry Stack

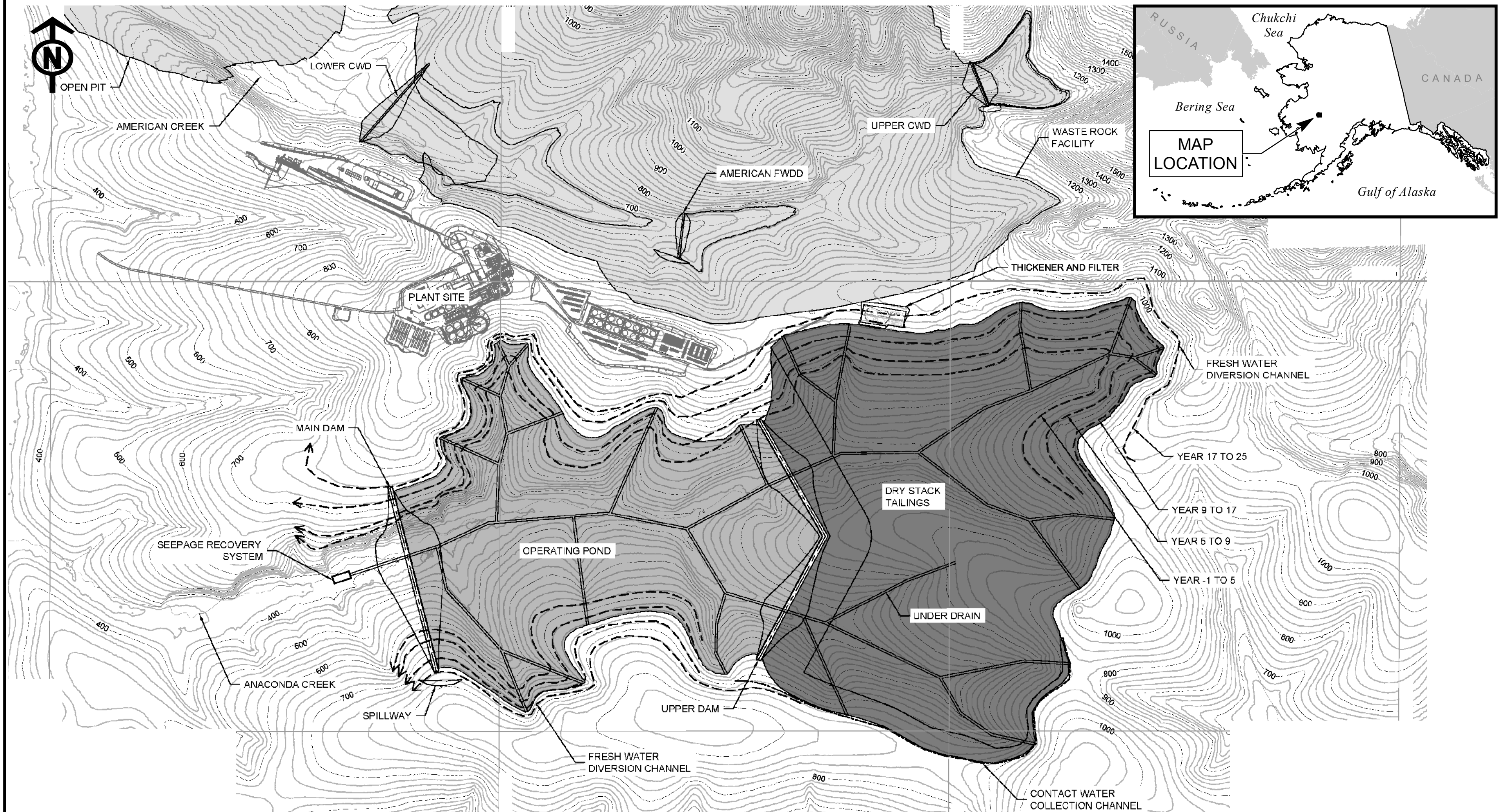
Construction; and Operations and Maintenance

The following is a summary of the requirements for the unlined dry stack TSF design basis related to surface water management (BGC 2014a):

- Dry stack tailings facility must store the life-of-mine filtered tailings;
- Operating pond must store the excess water accumulating in the site and water resulting from the filtration of the slurry tailings, the inflow design flood, freeboard, off-spec tailings (assumed 5 percent) and 1 year of contingency;
- The operating pond would have an emergency spillway designed to convey the probable maximum flood;
- Seepage through the TSF must be captured and contained;
- SRS is sized to store 3 days of maximum seepage flow, consisting of base groundwater flows and infiltration through the dry stack collected and conveyed through rock drains; and
- Diversion channels are designed to convey the 200-year peak instantaneous flow.

Similar to Alternative 2, fresh water diversion channels would be constructed around the dry stack to limit non-contact water from entering the TSF. A contact water collection channel would be located along the south perimeter of the dry stack and would drain into the operating pond. The SRS, located downstream of the main dam, would include a collection pond, diversion ditches, seepage recovery wells and a pump-back system. Runoff captured in the SRS is expected to be process-affected and would either be pumped to the process plant for use as process water or sent to the water treatment plant and discharged to Crooked Creek.

The dry stack impoundment would be developed from valley bottom up, and would extend a maximum length of 1.6 miles from the upper dam crest. The surface area of the dry stack would be approximately 1,500 acres, with an ultimate volume of 239,500 acre-feet. The dry stack impoundment under Option 1 would not be lined, and drainage through the tailings would enhance stability as the dry stack is built. The surface of the dry stack would be graded towards the operating pond to shed contact runoff water and decrease infiltration into the stack. A rock drain system would be placed in the main creek bed and major tributaries under the dry stack to intercept groundwater base flows and infiltration through the dry stack. The rock drain system would convey flow to the SRS located downstream of the main dam (Figure 3.5-32).



FRESH WATER DIVERSION CHANNEL

CONTACT WATER COLLECTION CHANNEL

UNDER DRAINS

Data Sources: BGC 2014

0 0.5 1 Miles

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ALTERNATIVE 5A DRY STACK TAILINGS FACILITY: WATER MANAGEMENT FEATURES

NOVEMBER 2015

FIGURE 3.5-32

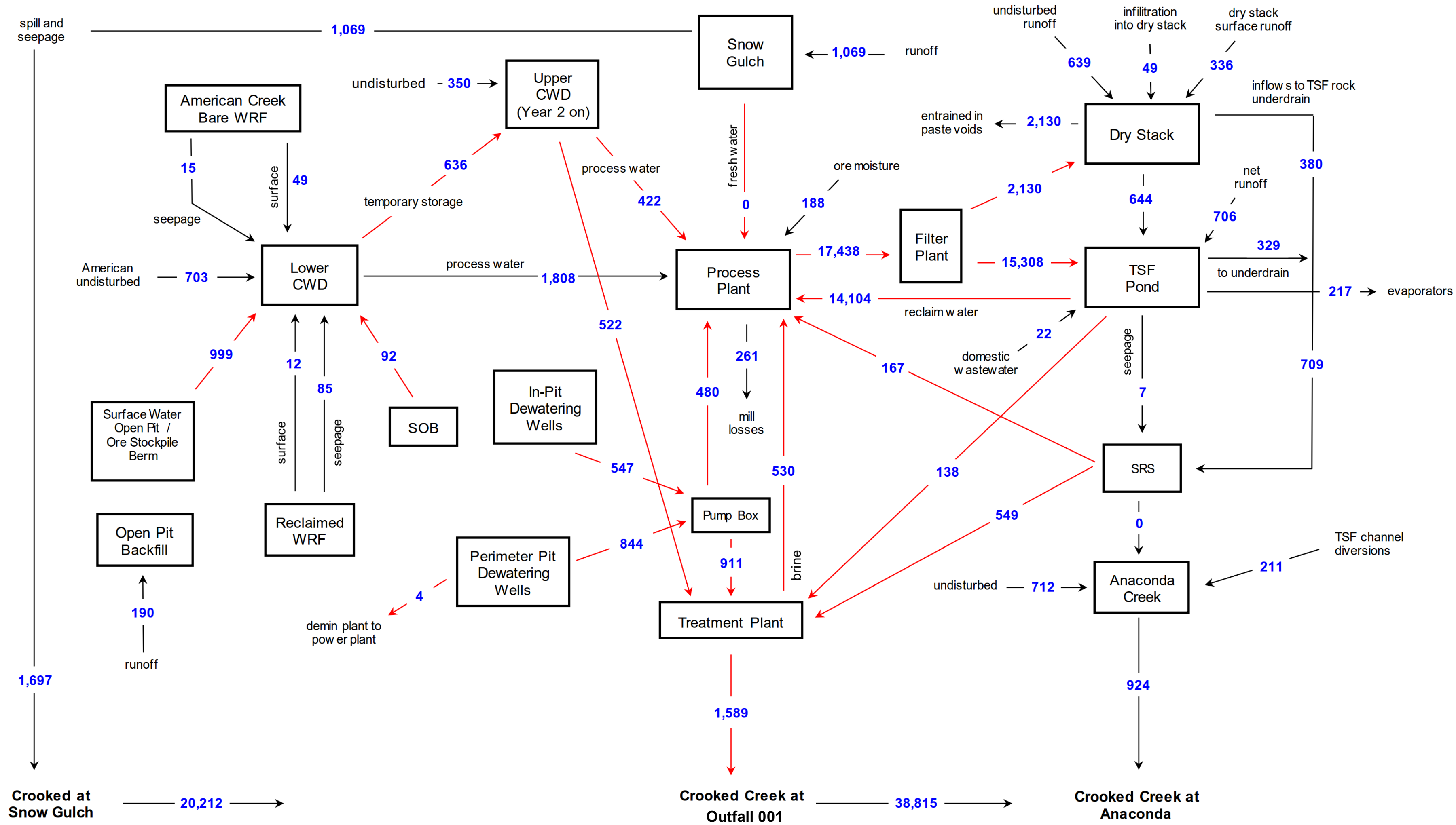
The average annual flow under Alternative 5A-Option 1 for mine water supply and distribution components used in the Anaconda Creek water balance (under average precipitation conditions) during mine operations is presented on Figure 3.5-33. While individual water balance components for contact water distribution vary compared to Alternative 2, the water balance strategy under Alternative 5A-Option 1 is essentially the same regarding contact water and treated water discharged to Crooked Creek during operations (BGC 2014j). Under Alternative 5A-Option 1, runoff from undisturbed ground would be discharged to Crooked Creek at an average annual rate of 924 gpm, compared to 1,048 gpm under Alternative 2. Since the dry stack impoundment is unlined under Alternative 5A-Option 1, inflows to the SRS from the rock drain system would average 709 gpm per year, compared to 615 gpm under Alternative 2. Water collected in the SRS is either used as process water or sent to the water treatment plant, reducing the need for freshwater from the Snow Gulch reservoir would decrease during operations under Alternative 5A. Therefore, water would be released from the Snow Gulch reservoir at an average annual rate of 1,069 gpm, compared to 1,032 gpm under Alternative 2. Treated water would be discharged to Crooked Creek under Alternative 5A-Option 1 at an annual average rate of 1,589 gpm, compared to 1,268 gpm under Alternative 2.

Closure, Reclamation, and Monitoring

Closure objectives of the TSF under Alternative 5A-Option 1 would be similar to those for Alternative 2, and the primary activities for closure include:

- Incorporation of an LLDPE geomembrane liner into a soil cover at closure;
- Grading the dry stack to the southeast to direct surface runoff to Crevice Creek (after Year 5 of reclamation, described below);
- Pumping the operating pond and off-spec tailings to the open pit so that the impoundment liner can be removed and the main (lower) dam regraded and revegetated;
- Installing an SRS downstream of the upper dam to collect contact water that seeps through the dry stack cover to the rock drain system; and
- Sending water from the SRS to the open pit, until seepage flow reduces to the point that the SRS may be able to be decommissioned. It is estimated that it would take roughly 200 years for seepage flow to reach the same rate as that predicted for the TSF under Alternative 2 (BGC 2015d).

Progressive reclamation would occur on the south and west facing slopes of the dry stack as construction advances. It is anticipated that reclamation of the dry stack tailings would occur over a 5-year period. During this reclamation period, surface runoff would be directed to the relocated SRS, where it would be pumped to the open pit. The cover surface will be graded to direct surface runoff to the southeast of the TSF. Surface runoff water would be held and tested for water quality. Similar to Alternative 2, it is assumed that a 5-year period would be necessary to demonstrate that water quality running off the cover is acceptable for discharge. Thus, during this period, all cover runoff will be pumped to the open pit (BGC 2014a). It is assumed that after Year 10 of closure, this water would be of suitable quality for discharge, and runoff from the pond will be permitted to drain to Crevice Creek from Year 11 of closure onwards via a spillway that will be excavated in the ridge dividing Anaconda and Crevice Creeks.



Note: Red arrows denote pumping routes. Values shown are in gpm. Note that all nodes do not balance, in particular the contact water dams and fresh water dam. These nodes do not balance as the dams either start with or end with a surplus of water.

Data Source: BGC 2015j

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ALTERNATIVE 5A SCHEMATIC WATER BALANCE DURING OPERATIONS - AVERAGE PRECIPITATION CONDITIONS

NOVEMBER 2015

FIGURE 3.5-33

The site water balance for Alternative 5A-Option 1 was developed for closure and post-closure time frames. The water balance model schematics for the model time frames listed below are presented on Figure 3.5-34 through Figure 3.5-37. Water management and water balance results are summarized below for each of the model time periods:

- Years 1 to 5 – Closure of TSF facility, all TSF water pumped to the open pit, flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an average annual rate of 1,526 gpm;
- Years 6 to 10 – Monitoring of surface water quality from the reclaimed TSF, all TSF water would continue to be pumped to the open pit, flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an annual average rate of 1,526 gpm;
- Years 11 to 41 – Surface runoff from the reclaimed TSF would be released to Crevice Creek without treatment (Section 3.7, Water Quality) at an average annual rate of 658 gpm (compared to 823 gpm under Alternative 2), flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an annual average rate of 1,526 gpm, and infiltration water would still be captured at the SRS and sent to the open pit; and
- Year 42 on – Surface runoff from the reclaimed TSF would be released to Crevice Creek without treatment at an average annual rate of 658 gpm, flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an annual average rate of 1,526 gpm, treatment of open pit water would commence, and treated water would be discharged to Crooked Creek at an average annual rate of 3,401 gpm.

The SRS pumping rate to the pit lake at closure under Alternative 5A-Option 1 is estimated to be 18 percent higher than the Alternative 2 pumping rate. The total amount of water (treated and non-treated combined) discharged to Crooked Creek under Alternative 5A-Option 1 after Year 42 of closure is estimated to be 5,585 gpm on an average annual basis, compared to 5,253 gpm under Alternative 2. The difference would result in an average annual increase of approximately 0.7 cfs discharged to Crooked Creek under Alternative 5A-Option 1 throughout post-closure. This represents water that, under Alternative 2, would be discharged as runoff to Crevice Creek, and water that would eventually flow through Anaconda Creek after the SRS meets state water quality standards (not expected under Alternative 5A-Option 1). Thus, the net volume of Crooked Creek flow reduction downstream of the mine in post-closure resulting from maintenance of the pit lake level would be the same as Alternative 2.

Option 2: Lined Dry Stack

Construction; and Operations and Maintenance

Under Alternative 5A-Option 2, the dry stack tailings would be underlain by a pumped overdrain layer throughout the footprint, with an impermeable LLPDE liner below. The rock underdrain and foundation preparation would be completed in the same manner as Alternative 2. During the operation phase, the overall water balance model shown on Figure 3.5-33 for Alternative 5A would be the same for both Option 1 and Option 2 (BGC 2015k).

Closure, Reclamation, and Monitoring

The closure objectives and primary activities that would take place at closure under Option 2 would be the same as Option 1, except that seepage collected in the rock overdrain in closure would report directly to the pit lake via pipeline (as opposed to the SRS under Option 1). An SRS would still be required downstream of the Option 2 dry stack to capture underdrain flow and potential seepage through the dry stack liner.

The site water balance for Alternative 5A-Option 2 was developed for closure and post-closure time frames. The water balance model schematics for the model time frames listed below are presented on Figure 3.5-38 through 3.5-41. Water management and water balance results are summarized below for each of the model time periods:

- Years 1 to 5 – Closure of TSF facility, all TSF water pumped to the open pit, infiltration water collected in the overdrain system (above the LLPDE) would be pumped to the open pit at an average annual rate of 70 gpm, and flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an average annual rate of 1,526 gpm;
- Years 6 to 10 – Monitoring of surface water quality from the reclaimed TSF, all TSF water would continue to be pumped to the open pit, infiltration water collected in the overdrain system (above the LLPDE) would be pumped to the open pit at an average annual rate of 70 gpm, and flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an annual average rate of 1,526 gpm;
- Years 11 to 46 – Surface runoff from the reclaimed TSF would be released to Crevice Creek without treatment (Section 3.7, Water Quality) at an average annual rate of 658 gpm (compared to 823 gpm under Alternative 2), infiltration water collected in the overdrain system (above the LLPDE) would be pumped to the open pit at an average annual rate of 65 gpm, and flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an annual average rate of 1,985 gpm; and
- Year 47 on – Surface runoff from the reclaimed TSF would be released to Crevice Creek without treatment at an average annual rate of 658 gpm, infiltration water collected in the overdrain system (above the LLPDE) would be pumped to the open pit at an average annual rate of 39 gpm, flows from undisturbed ground in Anaconda Creek would discharge to Crooked Creek at an annual average rate of 1,985 gpm, treatment of open pit water would commence, and treated water would be discharged to Crooked Creek at an average annual rate of 2,959 gpm. Seepage flow through the liner under Option 2 that reports to the SRS is estimated to be similar to that of the TSF liner under Alternative 2.

The total amount of water (treated and non-treated combined) discharged to Crooked Creek under Alternative 5A-Option 2 after Year 46 of closure is estimated to be 5,602 gpm on an average annual basis, compared to 5,585 gpm under Alternative 5A-Option 1, and 5,253 gpm under Alternative 2. The difference would result in an average annual increase of approximately 0.8 cfs discharged to Crooked Creek under Alternative 5A-Option 2 (compared to Alternative 2) throughout post-closure. This represents water that would be discharged as runoff to Crevice Creek, and water that would eventually flow through Anaconda Creek after the SRS meets state water quality standards. Thus, the net volume of Crooked Creek flow reduction downstream of the mine in post-closure resulting from maintenance of the pit lake level would be the same as Alternative 2.

Summary of Mine Site Impacts – Alternative 5A

Stream flow and runoff alterations of water in the American, Anaconda, and Snow Gulch drainages under Alternative 5A Options 1 and 2 would be essentially the same as Alternative 2 during construction, operations, and the early closure period. During post-closure, increased water diversions from the TSF and SRS to the pit lake under Alternative 5A-Option 1 would result in slightly less flow to Crevice Creek and Anaconda Creek and slightly more treated discharge to Crooked Creek compared to Alternative 5A-Option 2, but overall flow reduction effects in Crooked Creek downstream of the mine would be similar to Alternative 2. Thus, overall effects under Alternative 5A Options 1 and 2 on surface water hydrology are expected to be the same as Alternative 2, i.e., minor to moderate.

3.5.3.6.2 TRANSPORTATION FACILITIES

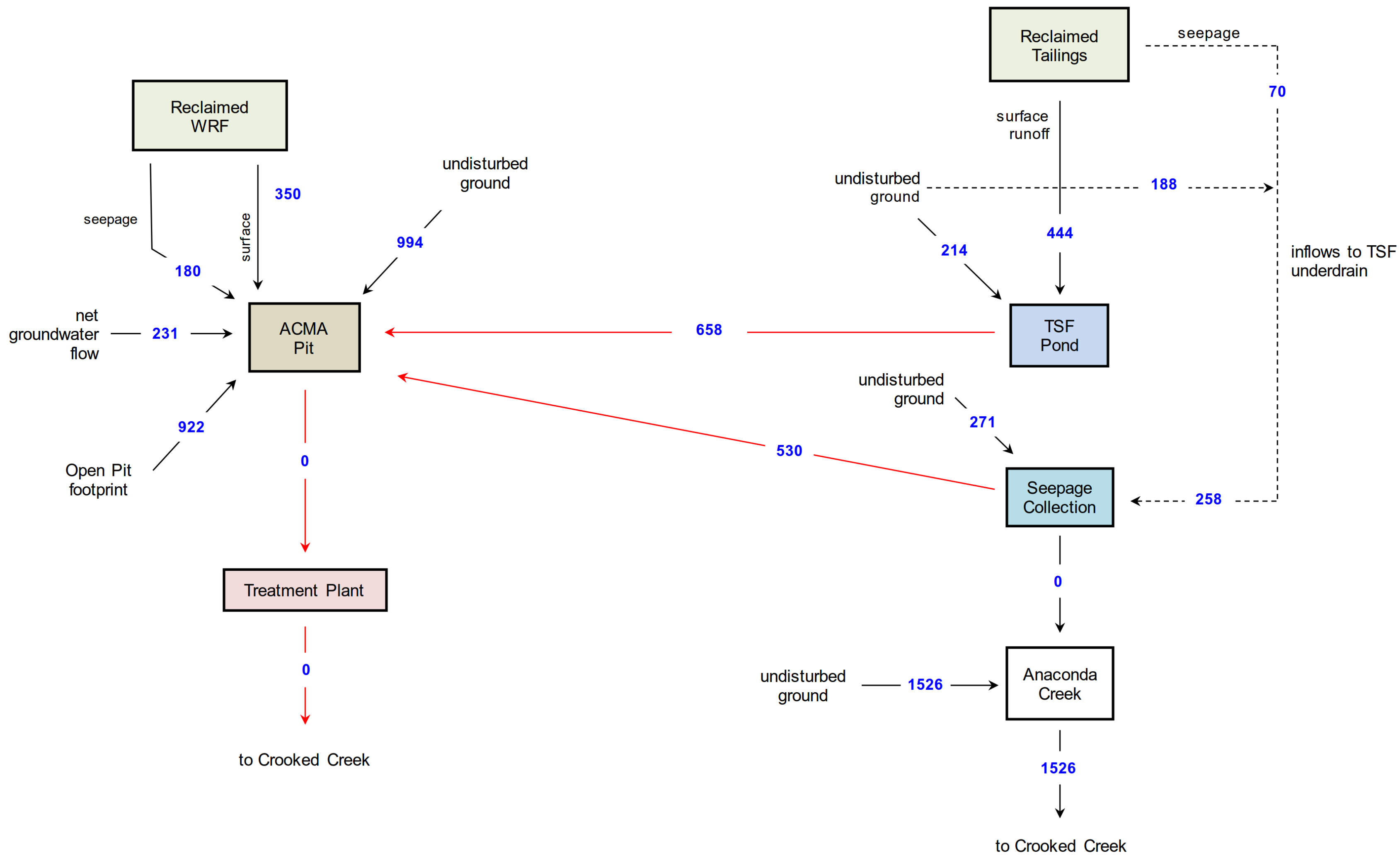
Alternative 5A requires additional earth moving equipment, filter plant infrastructure, consumables, and fuel for tailings transportation and placement relative to Alternative 2. All of these items are transported to the site via barge on the Kuskokwim River. Consequently, it is estimated that on average an additional 27 barges, or approximately 7 barge tow trips, would be required annually to support the dry stack alternative. This represents an increase of 6 percent in barge traffic on the Kuskokwim River under Alternative 5A from Alternative 2. The potential impacts to the Kuskokwim River from barge transportation would be the same as those described under Alternative 2; however, the increased number of barge trips per season could increase the direct and indirect impacts due to a longer shipping season, increased barge stranding potential, barge-induced bank erosion, and sediment disturbance from propeller wash. The barge transportation loading and tow configuration plan described under Alternative 2 would be applied to the additional barge trips under Alternative 5A. Based on a 6 percent longer shipping season of 117 days, there is still a greater than 90 percent probability that shipping could be accomplished within historical breakup and freezeup dates (see Table 3.26-6, Climate Change) without the need for low water travel below 39,000 cfs. Therefore, the range of magnitudes of direct and indirect impacts of barge transportation on the Kuskokwim River under Alternative 5A is expected to be the same as that of Alternative 2, i.e., low to medium.

3.5.3.6.3 NATURAL GAS PIPELINE

Impacts to surface water resources associated with the construction, operations, and closure of the natural gas pipeline under Alternative 5A would be the same as discussed under Alternative 2.

3.5.3.6.4 SUMMARY OF IMPACTS – ALTERNATIVE 5A

The implementation of Alternative 5A would have minor to moderate impacts on surface water in the proposed Project Area. Impacts associated with climate change would be the same as those discussed for Alternative 2. The effects determinations take into account applicable impact-reducing design features and BMPs, as discussed in Alternative 2. Additional mitigation and monitoring measures have been identified to reduce effects to surface water, and if they were adopted the intensity of impacts could be reduced; the overall summary impact rating would be the same as Alternative 2, minor.



Note: Values (gpm) shown are averaged over Years 6 to 10 of closure (the TSF pond monitoring period).
Red arrows denote pumping routes.

Data Source: BGC 2015k

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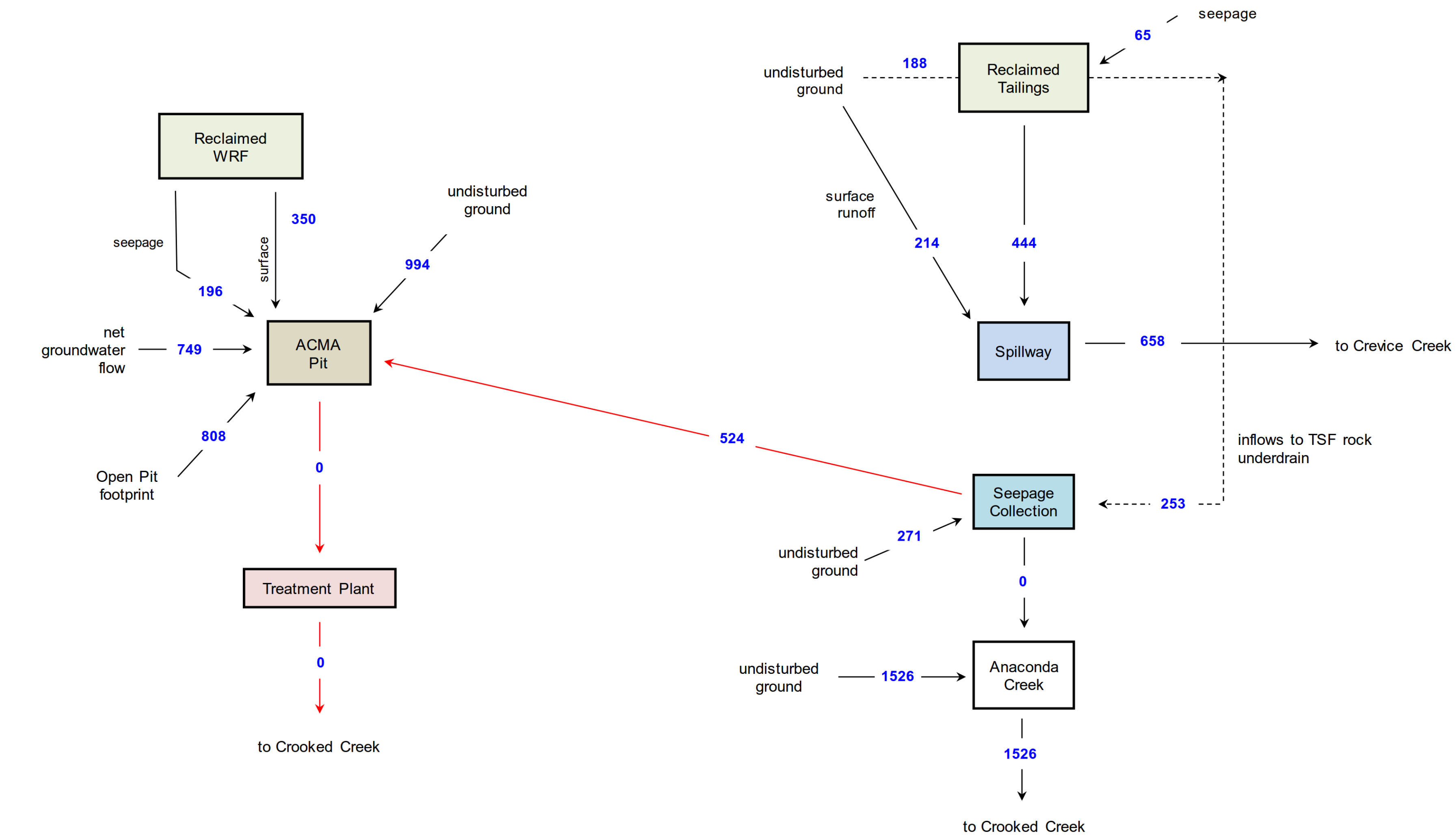
ALTERNATIVE 5A - OPTION 1
SCHEMATIC WATER BALANCE
DURING CLOSURE: YEAR 6 - 10

NOVEMBER 2015

FIGURE 3.5-35



Note: Values (gpm) shown are averaged over Years 11 to 42 of closure (TSF seepage water continue to be collected and pumped to ACMA Pit). Red arrows denote pumping routes.

Data Source: BGC 2015k

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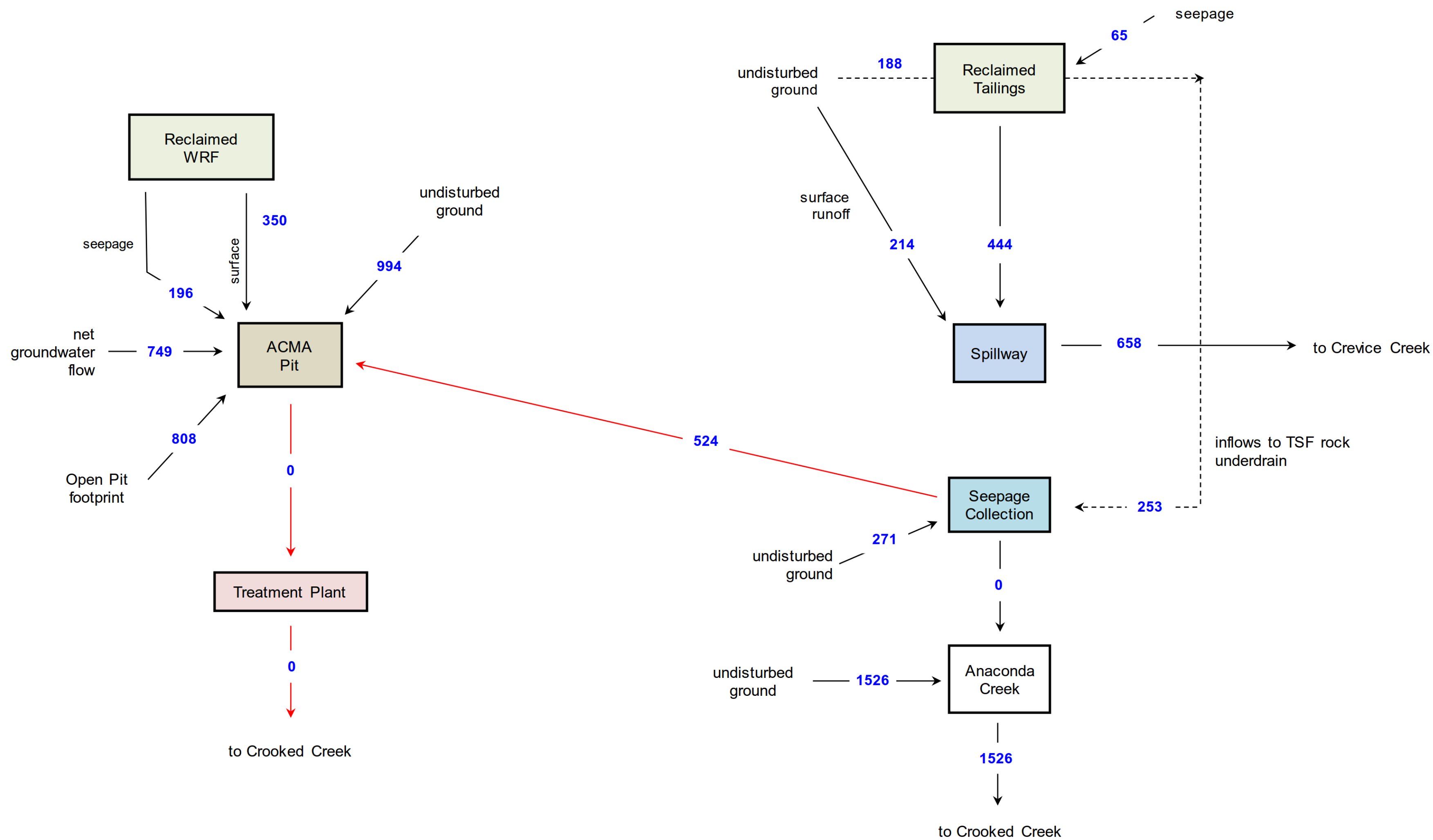
ALTERNATIVE 5A - OPTION 1
SCHEMATIC WATER BALANCE
DURING CLOSURE: YEAR 11 - 42

NOVEMBER 2015

FIGURE 3.5-36



Note: Values (gpm) shown are averaged over Years 11 to 42 of closure (TSF seepage water continue to be collected and pumped to ACMA Pit). Red arrows denote pumping routes.

Data Source: BGC 2015k

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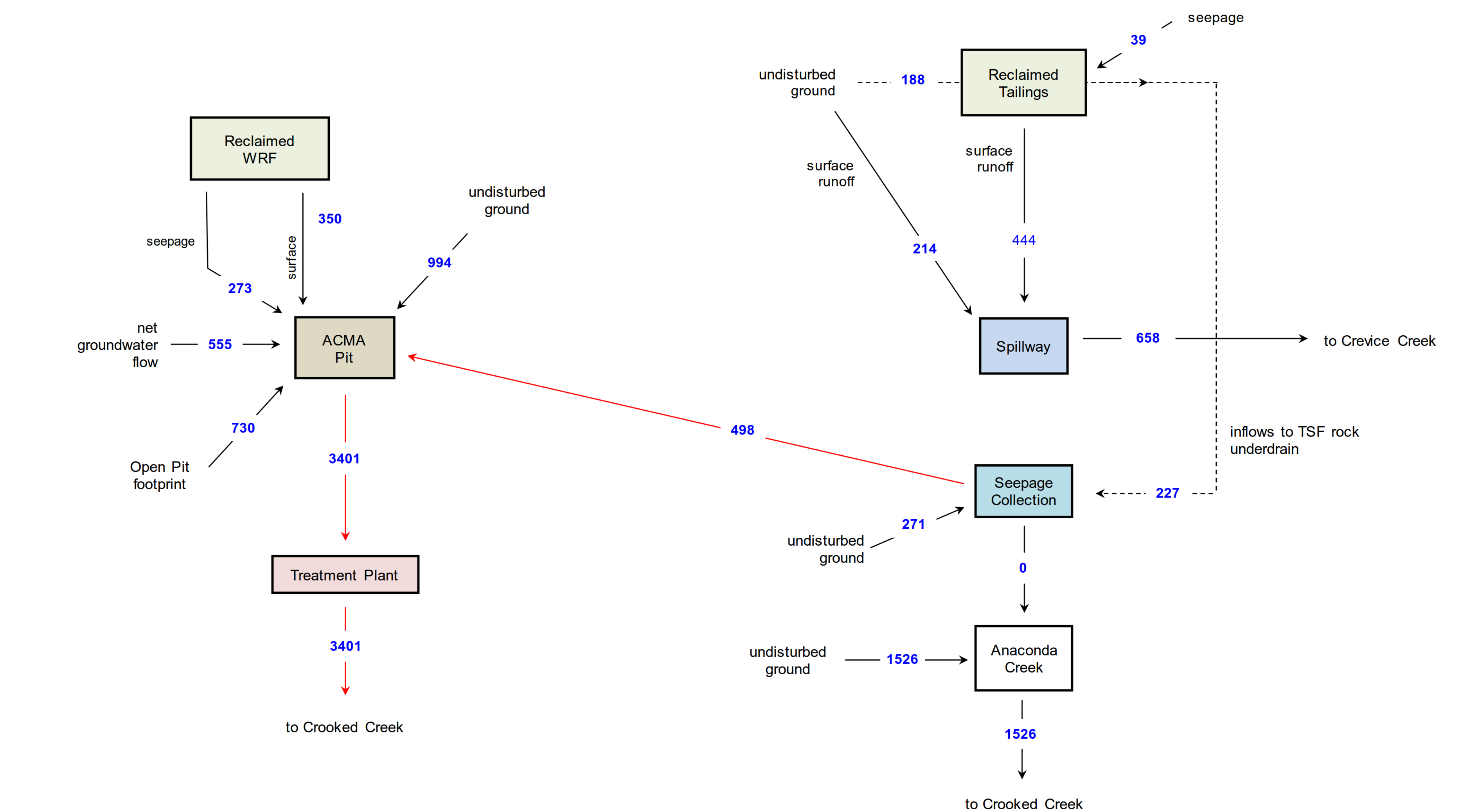
ALTERNATIVE 5A - OPTION 1
SCHEMATIC WATER BALANCE
DURING CLOSURE: YEAR 11 - 41

NOVEMBER 2015

FIGURE 3.5-36



Note: Values (gpm) shown are averaged over Years 43 to 200 of closure. Red arrows denote pumping routes.

Data Source: BGC 2015k

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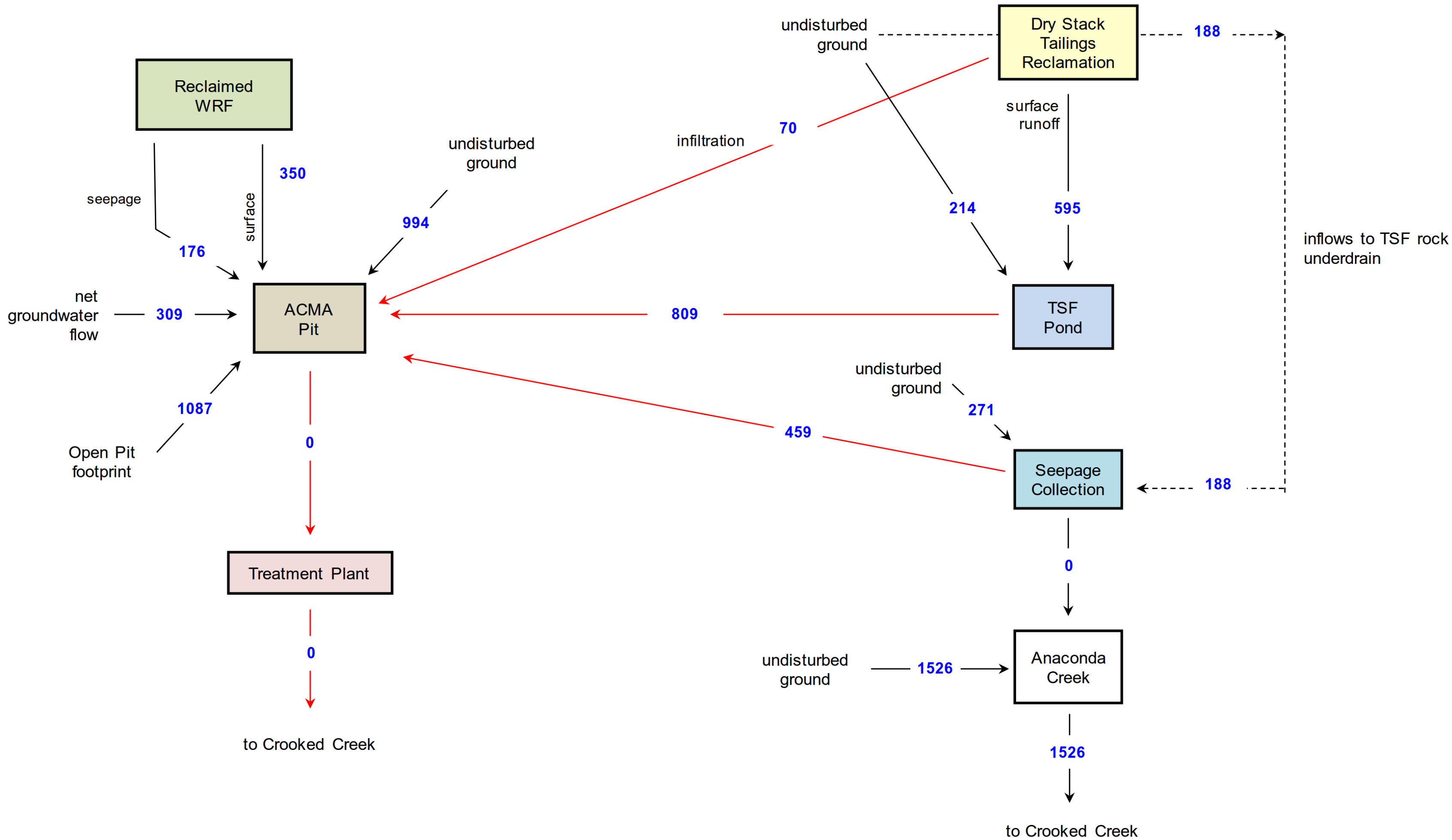
ALTERNATIVE 5A - OPTION 1
SCHEMATIC WATER BALANCE
DURING CLOSURE: YEAR 42 ON

NOVEMBER 2015

FIGURE 3.5-37

TSF impoundment volume pumped to ACMA Pit at end of Operations 125,340 acre-ft
Runoff accumulated in open pit backfill during Operations 8,960 acre-ft



Note: Values (gpm) shown are averaged over Years 1 to 5 of closure. Red arrows denote pumping routes.

Data Source: BGC 2015k

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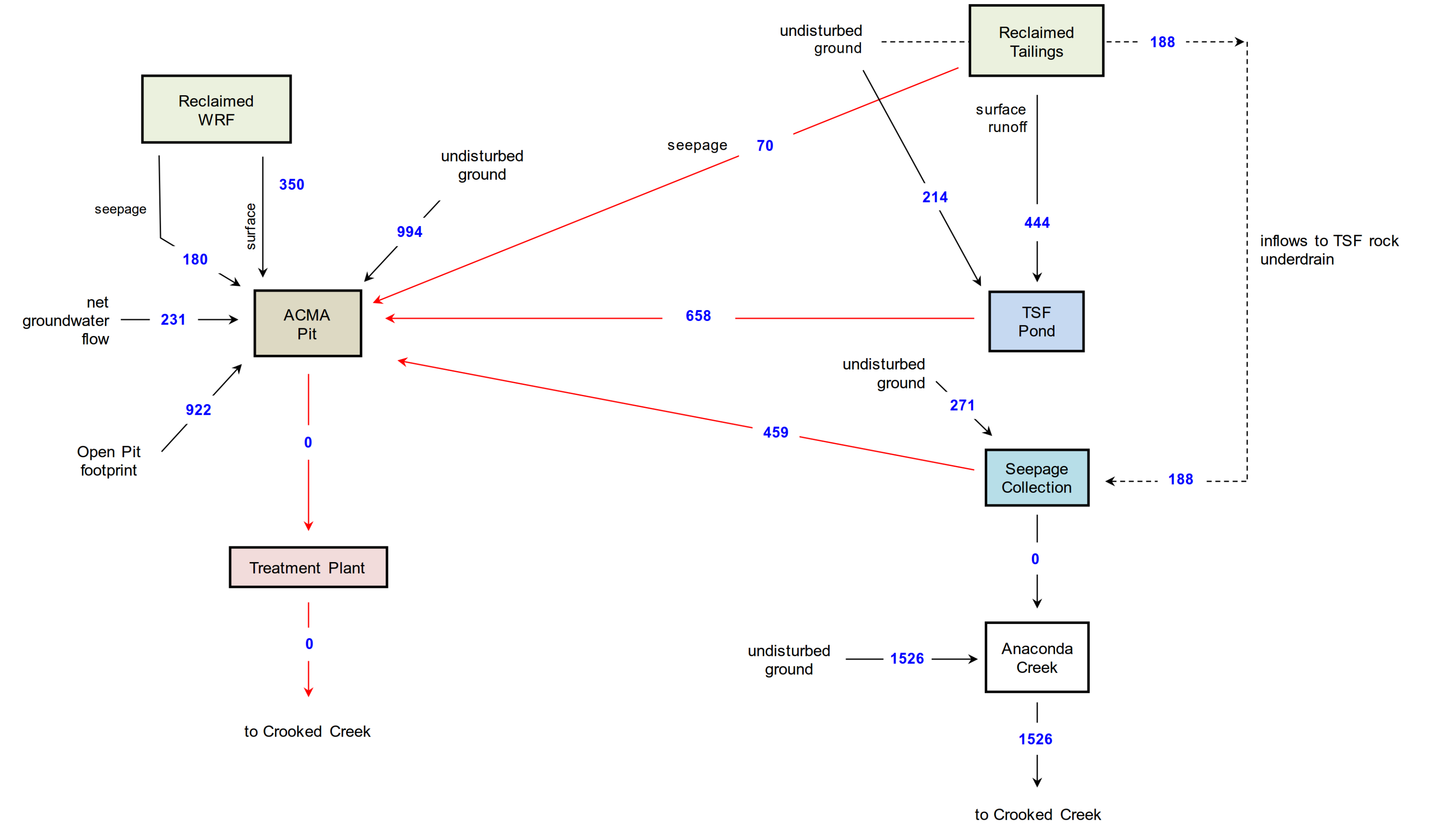
ALTERNATIVE 5A - OPTION 2
SCHEMATIC WATER BALANCE
DURING CLOSURE: YEARS 1 TO 5

NOVEMBER 2015 FIGURE 3.5-38



Note: Values (gpm) shown are averaged over Years 6 to 10 of closure (the TSF pond monitoring period). Red arrows denote pumping routes.

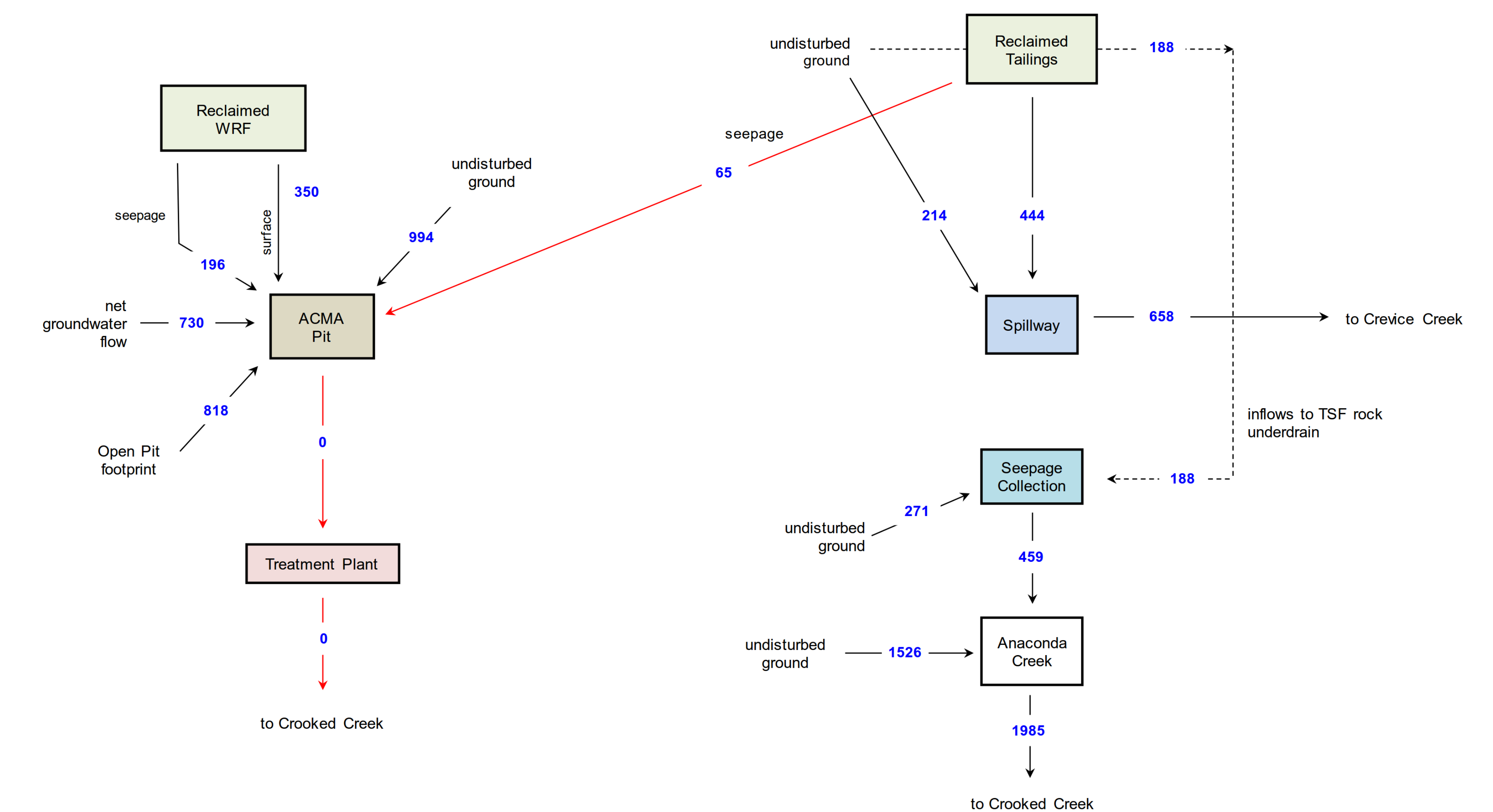
Data Source: BGC 2015k

DONLIN GOLD PROJECT EIS

ALTERNATIVE 5A - OPTION 2 SCHEMATIC WATER BALANCE DURING CLOSURE: YEAR 6 - 10

NOVEMBER 2015

FIGURE 3.5-39



Note: Values (gpm) shown are averaged over Years 11 to 46 of closure (TSF seepage water continue to be collected and pumped to ACMA Pit). Red arrows denote pumping routes.

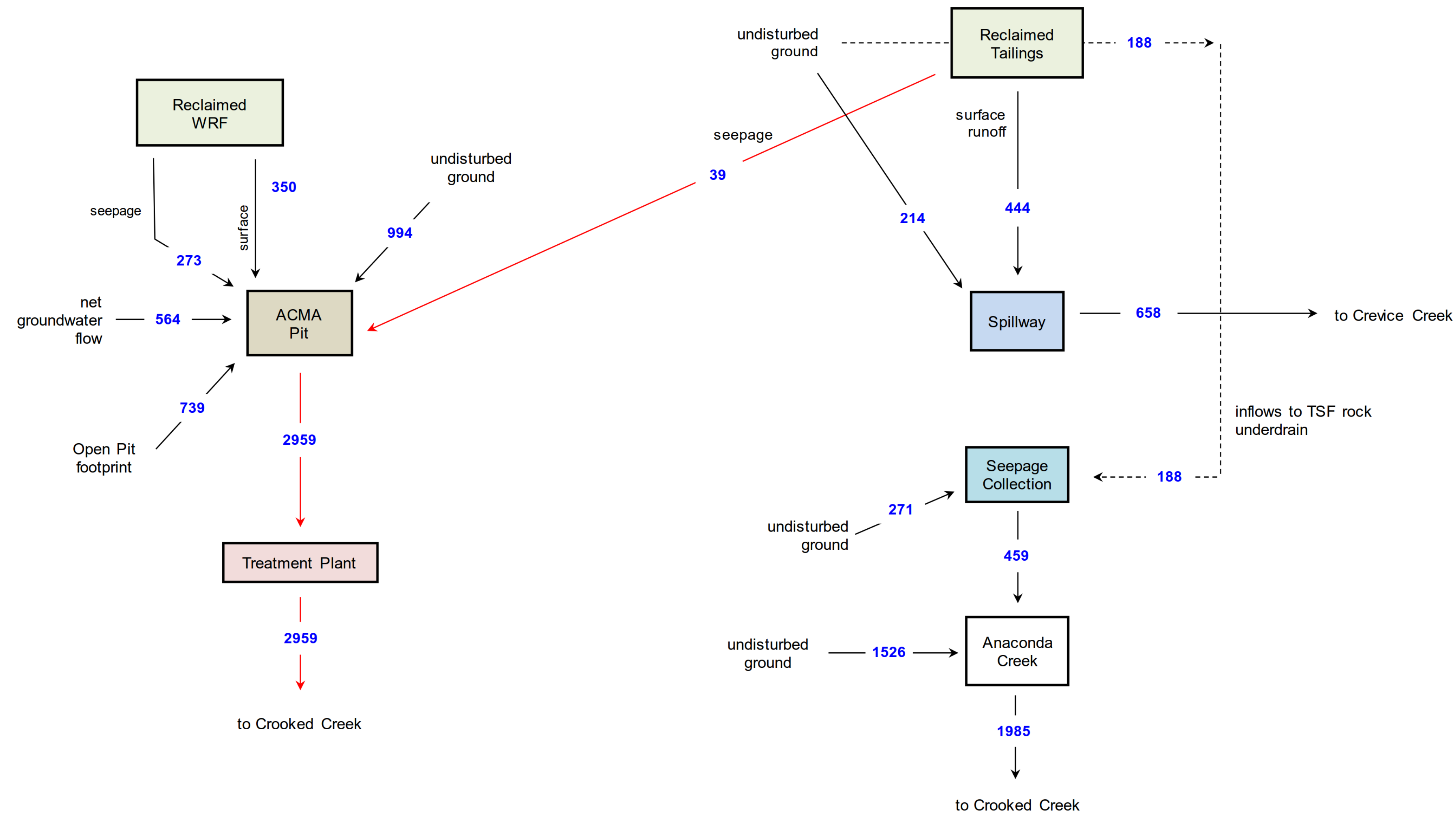
Data Source: BGC 2015k

DONLIN GOLD PROJECT EIS

ALTERNATIVE 5A - OPTION 2 SCHEMATIC WATER BALANCE DURING CLOSURE: YEAR 11 - 46

NOVEMBER 2015

FIGURE 3.5-40



Note: Values (gpm) shown are averaged over Years 47 to 200 of closure. Red arrows denote pumping routes.

Data Source: BGC 2015k

DONLIN GOLD PROJECT EIS

ALTERNATIVE 5A - OPTION 2 SCHEMATIC WATER BALANCE DURING CLOSURE: YEAR 47 ON

NOVEMBER 2015

FIGURE 3.5-41

3.5.3.7 ALTERNATIVE 6A – MODIFIED NATURAL GAS PIPELINE ALIGNMENT: DALZELL GORGE ROUTE

Mine Site and Transportation Facilities

Surface water quantity impacts pertaining to the mine site and transportation facilities under Alternative 6A are the same as those described under Alternative 2.

Natural Gas Pipeline

The pipeline route under Alternative 6A would cross a total of 377 streams and drainages, compared to 400 streams and drainages crossed along the Jones River (preferred) route under Alternative 2. The total pipeline length of the Dalzell Gorge route is very similar to Alternative 2, but is approximately 1 to 2 miles shorter. Alternative 6A would include a 2-mile HDD crossing through Dalzell Gorge and a 0.3-mile HDD under the Happy River. Alternative 2 may include HDD crossings along the Threemile Creek / Jones River portion; however, the lengths of which would be determined in a later design phase.

Like Alternative 2, potential impacts to surface water under Alternative 6A from clearing and grading within the construction ROW at stream crossings includes increased runoff, erosion, and sedimentation due to removal of vegetation and soil compaction from equipment. Upon completion of restoration and stabilization, pipeline construction would not be expected to result in long-term noticeable alterations to stream flow, stream profile, or structural components of streams and other water bodies crossed by the pipeline. For most stream crossings, temporary disturbances to water bodies would be limited to the construction phase. Stream beds, banks, and riparian areas would be restored to pre-project contours and configurations to the maximum extent possible. Channel banks and riparian areas would be re-vegetated to prevent erosion and maintain bank stability.

The effects of river scour at pipeline stream crossings would be the same or less than Alternative 2, as there would be fewer stream crossings in the high scour hazard areas of the Alaska Range (e.g., Figure 3.3-4). However, the design of burial depths would use the same approach under both alternatives; thus, the magnitude of potential effects is expected to be the same for both alternatives.

Between MP 84 and MP 142, the pipeline would cross the Iditarod National Historic Trail corridor at 34 locations and be co-located with it for about 14.5 miles (Table 3.16-5, Recreation). As described in Section 3.5.3.2.3, localized glaciation or aufeis is known to occur in this area in winter, and can accumulate about 1 to 10 feet thickness of solid ice (BLM 2015d), a situation which could be exacerbated by the co-located pipeline ROW and be hazardous for trail users. The glaciation can be from both natural and manmade causes. For example, the "Post River Glacier" occurs naturally on the Iditarod National Historic Trail immediately north of the Post River at about MP 141 on the Alternative 6A route. While BMPs and regular operations and maintenance activities would minimize these effects, glaciation impacts to trail users along co-located ROW segments could occur more frequently along Alternative 6A than Alternative 2 due to the greater number of trail crossings and co-located segments.

The effects of water use during pipeline construction and lack of winter water availability data could be exacerbated under Alternative 6A by having fewer streams available for extraction. However, the assumption of additional data collection in final design for water withdrawal permitting would apply to Alternative 6A, and like Alternative 2, is expected to reduce the magnitude of water use effects to low magnitude. Thus, the direct and indirect impacts for the pipeline component under Alternative 6A are expected to be essentially the same as Alternative 2; i.e., minor overall.

3.5.3.7.1 SUMMARY OF IMPACTS – ALTERNATIVE 6A

The implementation of Alternative 6A would have minor to moderate impacts on surface water in the proposed Project Area. Impacts associated with climate change would be the same as those discussed for Alternative 2.The effects determinations take into account applicable impact- reducing design features and BMPs, as discussed in Alternative 2. Additional mitigation and monitoring measures have been identified to reduce effects to surface water hydrology, and if they were adopted the intensity of impacts could be reduced to low or medium, as in Alternative 2. The summary impact rating would be similar to Alternative 2, minor.

3.5.3.8 IMPACT COMPARISON – ALL ALTERNATIVES

A summary of impacts from Alternative 2 is presented in Table 3.5-34, and a comparison between alternatives is presented below in Table 3.5-35. Although there are differences among alternatives in the Project components that would affect surface water quantity, they are relatively small. This is because all alternatives involve water diversion and storage, road and pipeline stream crossings, and barging. Overall there is little difference in the range of impacts to surface water resources for the various alternatives, as the scope and scale of the three project components are such that changes to a single mine structure, road, port, or pipeline route result in small changes to overall impacts.

Table 3.5-35: Comparison of Impacts by Alternative*

Impact-causing Project Component	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A –Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
Mine Site – Stream Flow in Operations	· Mostly low to medium magnitude impacts (e.g., Crooked Creek average annual flow reduction: 12% near American Creek, 5% near Bell Creek, under average precipitation conditions), · High magnitude effects on dammed Crooked Creek tributaries, and in Crooked Creek adjacent to mine (under below average precipitation and high K conditions)	Same ratings as Alt. 2	Same ratings as Alt. 2	Same ratings as Alt. 2	Same ratings as Alt. 2	Same ratings as Alt. 2
Mine Site – Stream Flow Post-Closure	· Mostly low to medium magnitude impacts in Crooked Creek (e.g., monthly flow changes range from -12% to +21% just below mine). · Localized high magnitude effects on permanently dammed tributaries.	Same ratings as Alt. 2	Same ratings as Alt. 2	Same ratings as Alt. 2	Overall, same ratings as Alt. 2 – slightly reduced discharge to Crevice Creek and Anaconda Creek during post-closure period; slightly increased treated water discharge to Crooked Creek at Outfall 001.	Same ratings as Alt. 2
Mine Site Summary	**Minor to Major** (during construction and operation), **Minor** (after closure)	**Minor to Major** (during construction and operation), **Minor** (after closure)	**Minor to Major** (during construction and operation), **Minor** (after closure)	**Minor to Major** (during construction and operation), **Minor** (after closure)	**Minor to Major** (during construction and operation), **Minor** (after closure)	**Minor to Major** (during construction and operation), **Minor** (after closure)

Table 3.5-35: Comparison of Impacts by Alternative*

Impact-causing Project Component	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A –Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
Transportation Infrastructure – Road and Ports	Mostly low magnitude impacts – Angyaruaq (Jungjuk) Port site 30-mile mine access road, 40 streams, 6 bridges, and 34 culverts	Same ratings as Alt. 2 with fewer fuel trucks on mine access road	Same ratings as Alt. 2 - addition of Tyonek Port site, reduced fuel trucks on mine access road	Same ratings as Alt. 2 - Birch Tree Crossing port site and 76-mile mine access road, 43 streams, 8 bridges, 35 culverts	Same ratings as Alt. 2	Same ratings as Alt. 2
Transportation Infrastructure – River	122 barge trips/year, 110 day barge season, 8 critical sections over 199 miles. Temporary, localized, medium magnitude impacts through operations (annual recovery expected for scour at critical sections); permanent low magnitude impacts post-closure (very reduced barging).	Same ratings as Alt. 2 - 83 barge trips/year, reduced barge-related impacts	Same ratings as Alt. 2 – 64 barge trips/year, fewest trips means least barge-related impacts	Same ratings as Alt. 2 - 122 barge trips/year, eliminates barge-related impacts upstream of Birch Tree Port; 3 critical sections over 124 miles	Same ratings as Alt. 2 – barge trips/year increase by 27, 117 day barge season	Same ratings as Alt. 2
Transportation Summary	**Minor**	**Minor**	**Minor**	**Minor**	**Minor**	**Minor**
Pipeline	315 mile-long natural gas pipeline, 400 stream/river crossings, mostly low magnitude impacts	Same ratings as Alt. 2	Same ratings as Alt. 2 - 334 mile-long diesel pipeline, 6 additional stream/river crossings, minor water use increase for pressure testing/ice roads/pads during construction	Same ratings as Alt. 2	Same ratings as Alt. 2	Same ratings as Alt. 2 - 314 mile-long natural gas pipeline, 377 streams crossings
Pipeline Summary	**Minor**	**Minor**	**Minor**	**Minor**	**Minor**	**Minor**

Notes:
* Alternative 1(No Action Alternative) would have no new impacts on Surface Water Hydrology.

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